DOCUMENT RESUME

ED 174 474 SE 028 546

AUTHOR Cost, Helen; And Others
TITLE Oakland County Science Safety Series: Reference Guide for Chemistry.
INSTITUTION Oakland County Schools, Pontiac, Mich.
PUB DATE 77
NOTE 121p.; For related documents, see SE 028 544-547; Not available in hard copy due to copyright restrictions; Contains occasional colored pages which may not reproduce well ; Guide prepared by the Division of Instruction
AVAILABLE FROM Oakland Schools, Division of Instruction, 2100 Pontiac Lake Road, Pontiac, Michigan 48054 ($8.50 complete set; $2.50 ea.)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Accident Prevention; *Chemistry; Laboratory Procedures; *Laboratory Safety; Safety; Safety Equipment; *School Safety; Science Education; *Science Instruction; *Secondary Education

ABSTRACT

This reference guide is intended to organize and suggest acceptable practices and procedures for dealing with safety in the area of chemistry instruction. It is intended as a resource for teachers, administrators and other school staff both in planning for science activities and in making daily decisions concerning safety. Sections include discussion of safety responsibility, safety training for students, chemicals, gases, heat sources, working with glass and plastics, accident prevention, and first aid. Several appendices deal with specialized considerations. (Author/RE)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

LaMoine L. Motz

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

ED174474

SE 028 546

The information and recommendations, both commercial and non-commercial, contained in this Reference Guide have been compiled from sources believed to be reliable and to represent the best opinion on the subject as of 1977. However, no warranty, guarantee or representation is made by Oakland Schools or the schools and school districts represented by educators involved in writing this guide as to the correctness or sufficiency of any information or recommendation herein, and Oakland Schools or the Oakland County Science Committee assumes no responsibility in connection therewith; nor can it be assumed that all necessary warnings and precautionary measures are contained in the Guide, or that other or additional information or measures may not be required or desirable because of particular or exceptional conditions or circumstances, or because of applicable federal, state or local laws.

Copyright © 1977, by Oakland Schools, Pontiac, Michigan. All Rights are Reserved. This publication, or parts thereof, may not be used or reproduced in any manner or form without the explicit, written permission of Oakland Schools. Inquiries should be directed to:

Division of Instruction
Oakland Schools
2100 Pontiac Lake Road
Pontiac, Michigan 48054

OAKLAND COUNTY

SCIENCE SAFETY SERIES

REFERENCE GUIDE

FOR

CHEMISTRY

Prepared by: Oakland Schools
Oakland County Science Committee
Safety Subcommittee

Principal Writer: Dr. Helen Cost, Bloomfield Hills

Division of Instruction
Oakland Schools
2100 Pontiac Lake Road
Pontiac, Michigan 48054

ACKNOWLEDGEMENTS

The Oakland County Science Safety Series Reference Guides were written during the summer of 1976 and substantially revised during the summer of 1977.

Oakland Schools wishes to express its appreciation to Helen Cost, Bloomfield Hills School District, for her excellent work on this revision.

Earlier versions were authored by: Roger Johnson, Waterford School District.

Oakland Schools also wishes to express its appreciation to:

Tim Falls	Novi Community School District
Roger Johnson	Waterford School District
Tom Krupka	Farmington Public School District
Betty Pogue	Rochester Community Schools
Ed Repucci	Walled Lake Consolidated School District
Larry Sabbath	Oak Park School District
John Schmitthausler	Lamphere Public Schools
Nancy Simanek	Farmington Public School District
Donald Maxwell	Oakland Schools
LaMoine Motz	Oakland Schools

Consultants:

Patrick Harris	Division of Occupational Health Michigan Department of Health
Ed Herndon	Safety Education and Training Division Michigan Department of Labor
Mike Izzo	Chief of the Warrant Division Oakland County Prosecutor's Office
Jack Kammeraad	Michigan Department of Education
Joseph Riley	Warren Van Dyke Public Schools

PREFACE

Teachers of science are in a unique position to assist students in understanding and appreciating the importance of safety education. Properly conducted classroom activities, experiments and demonstrations, teachers can show their students how to anticipate and cope with the problems of safety in science. Good instruction can establish a school environment in which safety awareness and practice grows and becomes an integral part of the lives of our students.

With this in mind, the Oakland County Science Safety Series Reference Guides have been developed for the Biological, Chemical, Physical and Elementary areas of science. The Science Safety Series can provide teachers and administrators with specific information in answering questions on safety practices, problems and responsibilities that are most likely to occur in the areas of science instruction, and they also provide assistance in developing a safe laboratory environment that does not, at the same time, unduly restrict scientific inquiry, activity and attitude.

This "Reference Guide" is designed to organize and suggest acceptable practices and procedures for dealing with safety in the area of science instruction. It is intended as a reference for teachers, administrators and other school staff both in planning for science activities and making "on the spot" safety decisions.

It should be emphasized that this guide is only a starting point for good practices. In no way does it intend to establish universal laws, regulations or rules. The contents presented have no legal implications, and should not be read as legal requirements. It is strongly recommended that the reader determine the legal liability of the teacher and/or administrator, as well as, pertinent local, state and federal laws and regulations. Further information on teacher liability can be found in Appendix A.

The working conditions of teachers are protected by the Michigan Occupational Safety and Health regulations (MIOSHA, Act 154 of 1974). Although MIOSHA regulations do not apply specifically to students, they do affect student laboratory safety conditions in an indirect manner. Further information on MIOSHA regulations can be found in Appendix B.

In addition, some school districts have operational statements concerning safety, and it is important that the administrator-teacher be aware of such policies and operating procedures as they relate to science.

TABLE OF CONTENTS

page

I. Responsibility for Safety

Introduction 1
A. Administration 2
B. Teachers 3
C. Students 5
D. Maintenance 6
E. Case Studies: How Would You Judge These Cases? 7
F. Checklist: Responsibility for Safety 8

II. Education and Training of Students for Laboratory Safety

Reference Page for Recommendations for Safety Education (Gray) 9
A. Education for Safety 10
1. Chemistry Laboratory Safety Rules and Safety Agreement (Sample 1) 10
2. Science Class Safety Agreement (Sample 2) 11
3. Science Class Safety Agreement (Sample 3) 12
4. Safe Practice Suggestions (Sample 4) 13
B. Analyze and Demonstrate for Safety 14
1. Lab Exercise Safety Analysis (Sample 5) 14
2. Recommended Lab Exercise Format (Sample 6) 15
3. Laboratory Safety Tips (Sample 7) 16
4. General Laboratory Safety Tips (Sample 8) 17
C. Waste Disposal: Sample Quiz Items 18
D. Emergency Procedures: Sample Quiz Items 19
E. Safety Laws: Sample Quiz Items 20
F. Know Your Basic Legal Responsibilities 21
G. Safety Education: Important References 22

III. Chemicals

Reference Page for Handling Chemicals (Yellow) 23
Introduction 24
A. What Can Be Done 24
B. Chemical Hazards 25
1. Carcinogens 25
2. Biological Poisons 26
a. Mercury 26
b. Heavy Metals and Their Salts 26
c. Organic Solvents 26
d. Common Gases 27
3. Incompatible Chemicals 27
4. Fire Hazards and Explosions 29
a. Fire Hazards 29
References 30
b. Explosive Hazards 30
Reference: In the Event of an Explosion 33
Reference: Putting Out Fires 33
C. Labeling of Chemicals 35
D. Chemical Storage 36
E. Handling Chemicals During Experiments 40
1. Procedures 40
2. The Laboratory Preparation of Oxygen 40
3. The Laboratory Preparation of Hydrogen 41
4. The Laboratory Preparation of the Halogens 41
5. Use of Nitrogen and Nitrogen Compounds 41

page

6. Use of Sulfur and Sulfur Compounds 42
7. Use of Phosphorus and Phosphorus Compounds 42
8. Preparation of Plastics 42
9. Soap Making 42
10. Thermite 43
11. Special Precautions in the Use of Perchloric Acid . 43
12. Safe Handling of Test Tubes 43
F. Chemical Spills 44
G. Safe Disposal of Chemicals 47

IV. Handling Gases

Reference for Gases, Heat Sources, Glass Tubing (Gold) . . . 49
Introduction 50
A. Bottled Gases 50
B. Gas Generation Experiments 50
C. Toxic and Combustible Gases 51

V. Working With Heat Sources

Introduction 52
A. Open Flames 52
B. Electrical Heating 52
C. Steam 53
D. Heat Resistant Materials 53

VI. Working With Glass and Glass Tubing and Plastics

A. Glassware 54
B. Glass Tubing 54
C. Frozen Glassware 56
D. Failure of Glassware 56
E. Laboratory Activities With Plastics 56

VII. Protection and Prevention

A. Safety Equipment and Facilities Checklist for School Science Laboratories 57
B. Safety Equipment and Facilities Checklist 61
C. Inspection: Laboratory Checklist 64
D. Student and Teacher Protection 66
1. The School Science Accident Problem 66
2. Behavior 66
3. Attitudes 66
4. Skills 67
5. Knowledge 67
6. Physical Impairments 67
E. Science Fair Activities 67
1. Rules and Regulations 67
2. Science Fairs 67
3. Selection of Project 68

VIII. First Aid

Reference Page for First Aid (Red) 69
Introduction 70
A. Emergency First Aid Procedures Checklist 71
B. 1. Breathing Failure 71
2. Shock 71
3. Burns 71

page

4. Cuts and Punctures 71
5. Fainting 71
6. Substance in the Eye 71
7. Substance in the Mouth 72
8. Electric Shock 72
9. Allergies 72
10. Other 72

B. First Aid Facilities and Supplies 73
C. Sample Accident Report Forms 74

Appendix A Liability and Teachers 78
Appendix B Michigan Occupational Safety and Health 80
Appendix C Handicapped Students 82
Appendix D Federal and State Laws 83
Appendix E Comparison Chart, Eye Protection Devices 84
Appendix F Explosives Research Section Safety Handbook 85
Appendix G Suppliers for Safety Equipment and Services 91
Appendix H Department of Labor Occupational Safety Standards 93

9

I. RESPONSIBILITY FOR SAFETY

Introduction

A district-wide science safety program must start at the highest level of administration and continue down through every level of the school community.

The members of the professional staff of the district must recognize and accept their moral and legal safety responsibilities and insist upon safe procedures in all science teaching areas.

Modern science instruction requires the active participation by the student. This raises safety questions not common to the more conventional course of study. Laboratory situations involving student participation are found at all grade levels.

One of the objectives of teaching science is to prepare students to function in a technological society. In such a society, a great many biological, chemical, and physical hazards exist. Therefore, it is natural that any instructional program will expose students to some potential dangers. It is the responsibility of the school to recognize these dangers, bring them to the attention of the students, and still allow the students to experience and discover the wonders of science.

Everyone involved in the administration, or teaching of a science program, should be aware of the federal, state, county, and local laws that apply to science teaching situations. (See Appendix D for listing of Federal and State laws).

Safety involves positive goals. The development and operation of a working safety program requires the active participation of all members of the educational community.

A. ADMINISTRATION

In order to achieve district or school safety goals the administration should:

1. Actively support and display a good attitude toward school safety. Interest must be vocal, visible, and continuous.
2. Establish a written district-wide safety policy and program.
3. Stress and enforce the district-wide safety policy. Hold in-service education sessions with the teachers of science concerning the district-wide safety policy and program. This should include first aid, fire prevention, general student protection (including personal protective equipment), and new safety procedures and considerations. This may mean the appointment of a safety committee and/or safety officers.
4. Be aware of rules governing teacher liability for classroom accidents, and include this topic in in-service and orientation sessions.
5. Assist and encourage the teacher to correct and avoid situations that could result in liability to the teacher and the school.
6. Provide for proper safety equipment in all science laboratories as directed by MIOSHA regulations.
7. Delegate responsibilities to the staff and ultimately to the students. Hold staff accountable for safety practices in their respective areas.
8. Analyze accident records in order to determine the most frequent causes of accidents and the more severe types of accidents. Take corrective measures to change accident-causing conditions.
9. Make safety literature, posters and safety promotional material available to all persons associated with the safety program.
10. Set up a program for the safety orientation for new personnel.
11. Instruct the maintenance department in the proper handling and disposal of science materials.
12. Overcrowding of classes should not be allowed in science laboratories. Consideration of whether overcrowding exists should take into account the physical size of a room, the arrangement of the furniture and the facilities in the room, the kind of activities that are being carried out in the room, and the number of students in the class.
13. Designate a safety officer for the science department.

B. TEACHERS

The real key to safety in the science class is the teacher. The teacher is responsible for being the leader in demonstrating and correlating safe practices in the science areas. The teacher should:

1. Be aware of the district-wide safety policy. Become familiar with implications of MIOSHA regulations as they apply to teaching duties.
2. Adhere to the district-wide safety policy as it applies to the teacher and the students under his supervision.
3. Enforce district-wide safety procedures. This can be carried out by requesting a student practicing an unsafe act or creating an unsafe condition to promptly correct the hazard. Failure to comply could result in suspension or cancellation of lab privileges. Report MIOSHA violations to the proper administration.
4. Understand the teacher's relationship to the system-wide safety committee or safety supervisor.
5. Maintain safe working conditions, promote safe working methods, enforce the use of personal protective equipment and regulations, and establish the proper attitude toward safety in the classroom. The teacher should have the authority to close down a laboratory for the day, if he feels the environment is hazardous to the students' well-being.
6. Know their spheres of responsibility and authority in the area of safety. Be aware of the teacher's total responsibility in terms of operations, machines, personnel, maintenance, repairs, working conditions, and accident reporting.
7. Notify the administration of any potential hazards. Do not allow students to work under unsafe conditions.
8. Determine the qualifications for student assistants. Supervise student assistants.
9. Be aware of the safety considerations for each laboratory activity and instruct the students in this area prior to the start of each exercise.
10. Do not allow the students to experiment on their own without proper supervision.
11. Make safety suggestions to administrative safety supervisor.
12. Review all laboratory manuals to determine the type and extent of hazards introduced by the various experiments and procedures. Analyze all laboratory experiences for possible safety hazards prior to introducing the material to the students.
13. Read and post safety literature, posters and safety promotional material.
14. Assist new teachers in learning and using the school safety code.

15. Know the location of and be able to properly use all science safety devices.

16. Do not work alone in a science laboratory and do not allow students to work alone.

17. Pretest all devices and/or equipment brought into class by a student prior to allowing students to use such devices.

18. Consult people with special knowledge or experience if unsure about using a new technique, chemical, or equipment.

C. STUDENTS

Accidents can be prevented only by each individual working in the laboratory in a safe manner. The students should:

1. Follow the general safety policies of the school district.
2. Maintain safe working conditions as they apply to the individual and the group. Use personal protective equipment and follow personal protective regulations.
3. Be aware of the safety considerations for each laboratory activity prior to the start of each exercise. Follow the safety instructions while performing the laboratory exercise.
4. Survey the student work areas in order to anticipate potential hazards and then take preventive measures and/or report such hazards.
5. Make safety suggestions to the teacher or safety supervisor.
6. Read, learn and follow the safety materials that are posted in the science room.
7. Do not work alone in a science laboratory, or experiment on your own without proper supervision, nor use unfamiliar equipment.
8. Report all injuries to the teacher immediately regardless of how minor.
9. Learn to use science equipment correctly and safely. Work in such a manner that other students are not placed in a potentially dangerous situation.
10. Completely clean up all work areas at the completion of an exercise or laboratory period.

D. MAINTENANCE

The maintenance department of a district or school also has a role in the safety program. The maintenance department should:

1. Be aware of the district-wide safety policy.
2. Establish the maintenance of science areas as a high-priority item. Some responsible person should periodically inspect the science teaching areas for such maintenance items as gas leaks, storage problems, electrical outlets, safety signs, and any other potential hazards.
3. Learn the proper handling and disposal of science materials.
4. Keep all science areas equipped with the necessary science safety materials.
5. Be certain that the science equipment is secure during non-class hours after school, and at night. This is especially important if the school building is used after the end of the normal school day.

15

E. CASE STUDIES: HOW WOULD YOU JUDGE THESE CASES?

Each of the cases listed below was adapted from an actual situation where a science teacher was being sued for liability. As a member of the jury would you judge these teachers guilty or not? Assume that the relevant facts have been given. Place a check in front of each case in which you would vote for a guilty verdict. Answers at the end.

_____1. A biology teacher requested a student to bring a glass beaker from the back of the room to the demonstration table. The student fell and received serious wounds from the broken beaker.

_____2. A student in a chem lab injured himself while inserting glass tubing into a rubber stopper. The teacher had previously demonstrated and properly instructed all students concerning the method and dangers involved. The student attempted to force the glass tubing into the stopper and was injured when the tubing snapped and went through the palm of his hand.

_____3. During a physics lab a teacher stepped out of the room for a few minutes to obtain a reference book from the library. In his absence a serious accident occurred.

_____4. On a field trip a science teacher led his students across a precarious looking footbridge. The bridge collapsed and caused serious injury to several students.

_____5. A teacher asked two students to clean a chemical stockroom, warning them of an unlabeled jar of acid on a high shelf. A scuffle caused the acid to fall and the students were seriously burned.

_____6. A student was sent to the drugstore in his own car to purchase some hydrogen peroxide. On the return trip he hit another car when he ran a red light. The student had no insurance and he sued the teacher.

_____7. A student was asked to water the plants in the greenhouse lab adjoining the botany classroom. The student carried a glass bottle full of water, tried to climb a chair and was seriously injured when the chair collapsed. The chair was in good repair.

_____8. Three students in a chemistry class were making up a lab exercise on the preparation and properties of oxygen. The teacher told them to gather the materials necessary for the experiment and to follow the safety instructions in the writeup. Contrary to the written directions the students mixed potassium chlorate with red phosphorus and ferric oxide, and heated them with a bunsen burner. An explosion resulted. Several students were injured.

Answers: Guilty 3,4,6,8

From Nassau Co. Science Supervisor's Association's Vectors and Dialogues.

F. CHECKLIST: RESPONSIBILITY FOR SAFETY

_____Are there written safety procedures for all experimental and laboratory classroom areas?

_____Are safety practices monitored and equipment checked at least once a year? (person responsible)

_____Are the staff and students aware of good safety practices and do they practice them?

_____How many and what type of accidents occur in your area?

_____Are facilities safe and well equipped for safety?

_____Are persons who act in an unsafe manner in the lab situation suspended from class or prevented from doing experimental work?

_____Are students put into unsafe situations by overcrowding and/or inexperience?

_____Are emergency procedures known in advance?

_____Are improvement requests for safety purposes being fulfilled?

_____Are you attempting to do experiments that are beyond the capability of the equipment you have?

_____Are signs available for you to post in the laboratory?

STOP
SAFETY

REFERENCE PAGE FOR RECOMMENDATIONS FOR SAFETY EDUCATION

1. All students should be made aware of the safety rules for the chemistry laboratory at the start of the semester. For examples of forms to use with students see pages 10, 11, 12, and 13.

2. Each student's experiment should be analyzed for its potential dangers. For an example of a form see pages 14 and 15.

3. A list of safety rules should be posted in the work area of the laboratory. For an example of such a list see pages 16 and 17.

4. Safe laboratory procedures should include the proper disposal of waste. For a sample quiz see page 18. For further guidelines see page 47.

5. Students should be trained in emergency procedures. For a list of possible emergencies, see page 19.

6. What are the teacher's basic legal responsibilities? For statements on this topic see page 21.

HAVE YOU THOUGHT THROUGH A GOOD SAFETY PROGRAM?

DON'T IGNORE POTENTIAL HAZARDS!
©VOLK

A. Education for Safety

1. CHEMISTRY LABORATORY SAFETY RULES AND SAFETY AGREEMENT : SAMPLE 1 (1)

___ Protective glasses are required. You will not be permitted in the laboratory without them.

___ Some sort of laboratory apron, or coat is recommended to protect you and your clothing.

___ No running, or shouting is permitted in the lab.

___ Long hair must be secured away from your face and lab materials, especially chemicals and burners.

___ You should know the location, and how to use the fire extinguisher, eye wash, and fire blanket.

___ Always add acids to water, never water to acids when doing experiments.

___ Never return unused reagents to stock bottles unless specifically instructed to do so by your teacher.

___ Throw solids into designated waste jars.

___ Flush liquids down the sink with a large excess of water.

___ Place solvents in waste container marked for this purpose.

___ Always lubricate glass tubing, or thistle tubes before inserting them into a stopper. Always wrap toweling around glass tubing while inserting it into stoppers.

___ Be very cautious when testing for odors.

___ Never aim the opening of a test tube, or flask at yourself, or at anyone else. Aim it into the hood, or toward the window.

___ Use hoods whenever poisonous, or irritating fumes are evolved.

___ Never leave anything unattended while it is being heated, or is reacting rapidly. Do not leave bunsen burners burning unnecessarily. Do not leave gas generators alone, or operating after the desired gas has been collected. Do not use burners when they are not needed.

___ Makeshift equipment and set-ups are the first steps to an accident, avoid using them.

___ A clean lab is a safe lab! Return all material to the proper place and keep your work area clean.

___ At all times concentrate on what you are doing.

___ Report any accident to the teacher at once.

___ Students are not permitted in the labs without teacher supervision.

___ No food may be brought into the lab.

___ No smoking is permitted in the lab.

___ You should know and understand the dangers and hazards of each experiment before you start the experiment.

___ You should not do anything that will put another member of the class in a position of danger.

___ You should not mix chemicals together unless you have been instructed to do so by the teacher, or the instructions in an experiment.

---

2. SCIENCE CLASS SAFETY AGREEMENT: SAMPLE 2

I have read the above safety rules for Chemistry. I understand what they mean and my teacher has discussed them with the class.

class	date	student's name
teacher - hour		parent or guardian's name
		home phone
		business phone

(1) Oak Park High School, Oak Park, Michigan 1976.

3. **SCIENCE CLASS SAFETY AGREEMENT:** SAMPLE 3

Students will be removed from the science activity area by the teacher if:

a. Their personal appearance or dress is such that they can cause injury to themselves, or to other students.

b. They are behaving in such a manner that they can cause injury to themselves, or to other students.

c. They are not following the prescribed safety rules for the science activity area, or the particular science activity being conducted.

d. They are going beyond the limits of the science activity into areas that may lead to an unsafe situation.

e. They have not completed the pre-experiment activities that will allow them to work safely in the laboratory situation.

I __________________ have read the above rules. I understand what they meant
Student Name
when they were discussed by my teacher, or I had the teacher explain them to me.

I _______________ have read the above rules. I have discussed them with my child and
Parent or Guardian
feel that my child understands what they mean and the consequences for removal from class. I would like to inform the school that my child has the following physical or medical situations that could affect their learning in a science class:

1. ____________________________

____
Home phone number

2. ____________________________

3. ____________________________

____
Business phone number

4. ____________________________

I _______________ have received a signed copy of this form from __________________
Teacher's signature   Student Name
on __________. A copy of this agreement was given to the student, and a copy put in
date
my files.

21

4. SAFE PRACTICE SUGGESTIONS: SAMPLE 4
General Laboratory Conduct in the Laboratory

I agree to:

1. Follow instructions explicitly.
2. Perform only authorized experiments.
3. Protect eyes, face, hands and body, long hair.
4. Practice good housekeeping.
5. Know where to get help fast.
6. Know location of first aid and fire fighting equipment.
7. Report at once all accidents and unusual occurrences.
8. Never "horse around". It's dangerous.
9. Ask questions, if I don't understand what to do.

I understand the need for safe attitudes and behavior in the laboratory. It is for my own and the protection of others. I agree to act within the limits of the posted rules.

Student name ______________________________

Parent name ______________________________

Teacher Name ______________________________

Date ______________________________

THE RULE IS: "NO HORSING AROUND"!
OK! OK! I'M LEAVING
FUNNY FARM

II. EDUCATION AND TRAINING OF STUDENTS FOR LABORATORY SAFETY

B. Analyze and Demonstrate for Safety

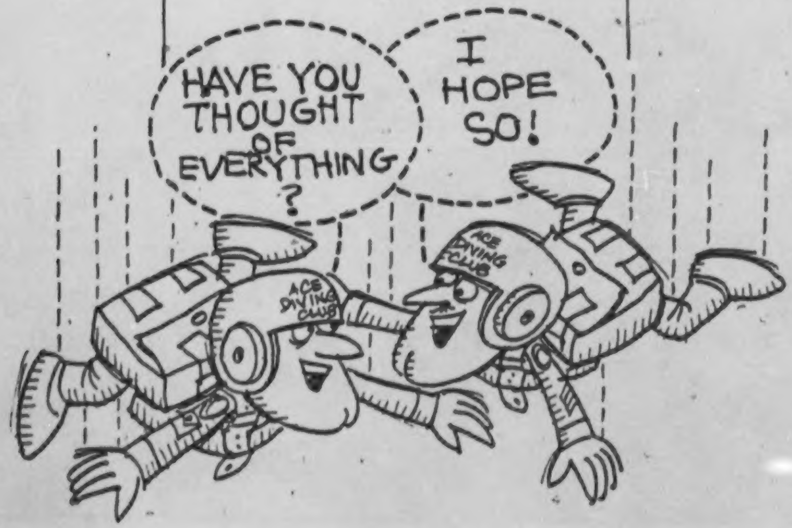
1. LAB EXERCISE SAFETY ANALYSIS: SAMPLE 5

A form such as the one below might be used for safety analysis of experiments and can be updated during the lab exercise when the students are actually making the mistakes that no instructor could possibly imagine or foresee.

Lab Exercise ____

Instructor ____________________________________

BASIC STEPS	POTENTIAL HAZARDS	RECOMMENDED SAFETY PROCEDURE
Break the experiment down into its basic steps; what's done first, what's done next and so on.	For each step, ask yourself what accidents could happen to the student performing the experiment.	For each potential hazard, ask yourself how the potential hazard or accident could be avoided.


HAVE YOU THOUGHT OF EVERYTHING?
I HOPE SO!
ACE DIVING CLUB
ACE DIVING CLUB

2. RECOMMENDED LAB EXERCISE FORMAT: SAMPLE 6 (1)

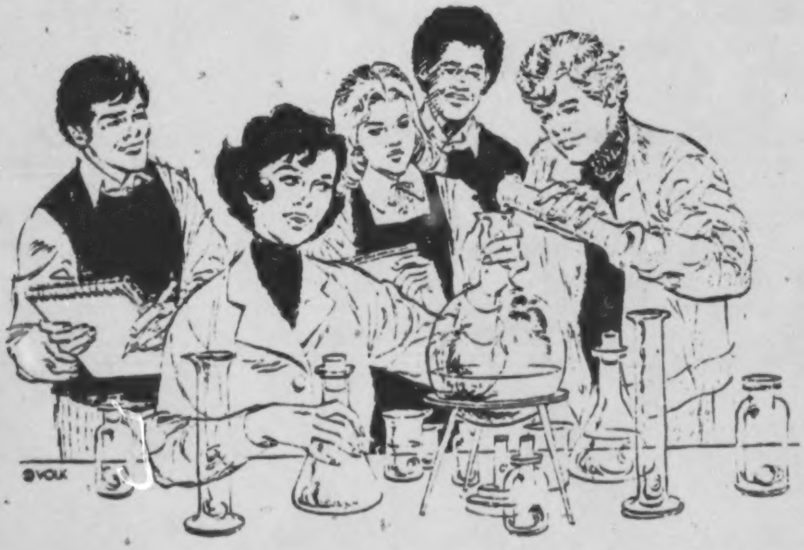
The following format clarifies and includes safety as part of science activities.

A. Prelaboratory Analysis and Information
  1. Safety
    a. Hazardous materials
    b. Safe procedures
  2. Possible difficulties

B. Laboratory
  1. Time required
  2. Chemicals per student
  3. Equipment per student
  4. Representative Data
  5. Representative Conclusion
  6. Alternate or optional experiments or procedures.

C. Answers to Problems and Questions

D. Definitely include debriefing and recommendations for improving the experiment, including safety procedures as a class discussion. (2)



WHAT'S WRONG OR RIGHT HERE ?

---

(1) "Modern Chemical Technology Teacher's Manual" Chem Tec Project Writing Team, R.L. Pecsok, Director. American Chemical Society, 1155 Sixteenth St. N.W., Washington, D.C. 20036, 1973.

(2) H. Cost, personal communication.

3. LABORATORY SAFETY TIPS: SAMPLE 7

Safety is your responsibility. You are working with materials that are extremely hazardous to the safety of everyone involved. Think safety--work safely!

Do. . . know the safety limits of the chemicals you will use: their flash points; their auto-ignition temperatures; and what to do if you might exceed these limits.

Do. . . check your equipment before you start. Then check each item again before you put it to use.

Do. . . protect your eyes, your face, your hands, your body. Always wear safety glasses, face guard, if necessary; proper gloves and protective clothing. Tie long hair back. Over-protect rather than under-protect yourself.

Do. . . practice good housekeeping. Keep your lab table clean and free from extraneous articles. Wipe up spills immediately. Dispose of waste in proper closed receptacles.

Do. . . know the location of eye baths, safety showers, respiratory equipment, fire extinguishers, fire-fighting materials and how to get to them fast.

Do. . . observe the signs that are posted or made for your protection.

Do. . . make safety a habit. THINK SAFETY . . . ALL WAYS! The safety habit is a good one . . . in school, on the job, at home, everywhere.

Don't Take Chances. . . avoid emergencies by carefully planning ahead before you start a job. Know every step and the possible hazards involved. Then prepare to defend against any emergency which may arise.

Don't. . . overlook toxicity. Consider every chemical as toxic and protect yourself accordingly. Take precautions against vapor hazards, corrosiveness, and possible burns.

Don't. . . fail to get the advice of your teacher if you are not completely familiar with the equipment you will use.

Don't. . . work alone in the laboratory.

Don't. . . overlook the possibility of splashing. Painful burns can result. Don't wear loose clothing, neckties, wrist watches, necklaces, long hair if you are working around an open flame.

Don't. . . wear rings or other jewelry as they may be exposed to chemical reactions.

Don't. . . panic if an emergency arises. Know the exits and get away fast from impending danger.

26

4. GENERAL LABORATORY SAFETY TIPS: SAMPLE 8

1. Follow instructions explicitly.
2. Perform only authorized experiments.
3. Protect eyes, face, hands, and body.
4. Tie back long hair.
5. Practice good housekeeping.
6. Know location of first aid and fire fighting equipment.
7. Report at once all accidents and unusual occurrences.
8. Never "horse around". It's dangerous.
9. Ask questions, if you don't understand what to do.

KNOW THE RULES

C. Waste Disposal: Sample Quiz Items

You might give this quiz to a class of students.

ARE YOU AWARE OF OUR SAFETY DISPOSAL SYSTEM? *

In this laboratory, where would you throw?

paper ____________________

broken glass ____________________

waste solid chemical ____________________

waste liquid chemical ____________________

nonflammable ____________________

flammable ____________________

used pieces of metal (Al, Cu) ____________________

spilled mercury ____________________

food ____________________

water left over from an experiment ____________________

28

*HC/77

D. Emergency Procedures: Sample Quiz Items

You might give this quiz to your students.

ARE YOU AWARE OF EMERGENCY ACTIONS AND PROCEDURES?

WHAT ACTIONS WOULD YOU TAKE IF . . . ?

1. Another students' clothing or hair caught on fire.
2. A student spilled strong acid or alkali on the front of his/her clothes.
3. A student splashed a strong chemical in his/her eye.
4. A student accidentally ate some chemical compound.
5. A student felt faint.
6. A student actually fainted and fell down on the floor.
7. A small paper fire started on the desk top where a student was working.
8. Gas generating equipment seems to be clogged.

Answers may be found in section on FIRST AID, page 72 .

DO YOU KNOW WHAT TO DO?

WHAT SHOULD I DO?
TURN TO P.70 FOR FIRST AID.

E. SAFETY LAWS: SAMPLE QUIZ ITEMS

True or False

Did you know:

____ Safety goggles are required by law.

____ Safety goggles must be sanitized between use.

____ An apron must be worn during experiments.

____ Gloves must be used to handle chemicals.

____ Drinking fountains can also be used for eye washes.

____ Chemicals may be disposed of down the sink drain.

____ All chemical bottles must have proper labels.

Answers T, T, F, F, T, T, T

Information may be found in Appendix D.

F. Know Your Basic Legal Responsibilities

1. "Before a court will permit damages to be awarded, there must be actual loss or damage proximately caused by a breach of duty on the part of one from whom compensation is sought." (1)

   a) The duty imposed on the teacher of chemistry is the same as that imposed on every person.... he or she must act reasonably.

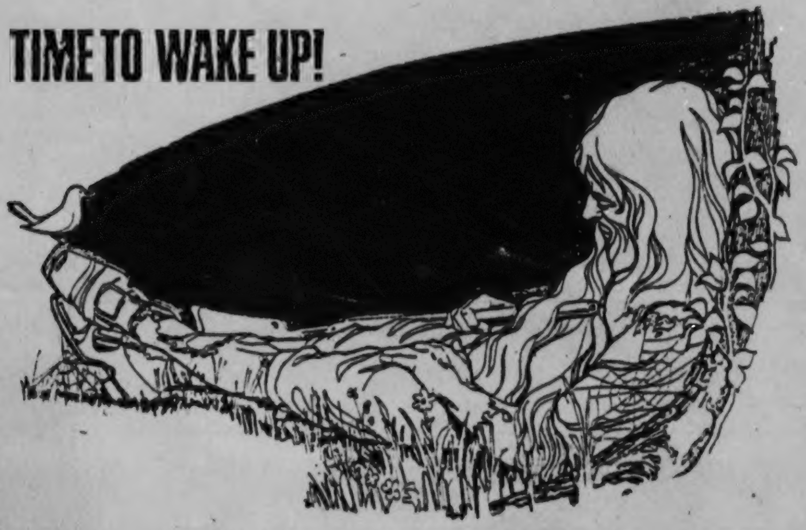
   b) It would be assumed by the court that the chemistry teacher would know:

      -general safety procedures.
      -safety hazards for laboratory experiments and procedures.
      -toxicity information on substances being used.
      -recommended standards for substance exposures.
      -the statutes requiring safety glasses and/or other equipment.
      -the general level of competence, experience, and information that the students possess.

   c) Further, for the chemistry teacher, the duty is seen as not exposing others to unreasonable risk.

   d) "It does not seem inherently unreasonable to expect that teachers will be present in classes in which they are entrusted to teach." (1)

   e) Comparative negligence may be judged as partial or complete depending on the percentage of fault that the claimant himself contributed to the injury. (Except for "horseplay", the student is generally not thought of as contributing negligence to a situation).


TIME TO WAKE UP!

(1) Sweeney, T.L., J. of Chem. Ed., Vol 54, No. 3, March, 1977, p. 134-136.

G. Safety Education: Important References

Have safety literature available for both staff and students' easy access.

1. Multiple copies of excellent safety pamphlets and quick information may be obtained from: National Safety Council, 425 North Michigan Avenue, Chicago, Illinois 60611.

   No. 59 Safety in the Chemistry Laboratory (stock # 429.04)
   No. 14 Chemicals
   No. 23 Laboratory Glassware
   Chemical Safety Slide Rule

2. Safety in Academic Chemistry Laboratories, American Chemical Society, January, 1976.

3. Handbook of Laboratory Safety, 2nd edition, Ed. N.V. Steere, The Chemical Rubber Company, 18901 Cranwood Parkway, Cleveland, Ohio 44128, 1971.

4. U.S. Department of Labor, Occupational Safety and Health Administration, August, 1975, 230 South Dearborn, 32nd Floor, Chicago, Illinois 60604

   Job Health Hazard Series

OSHA	2234	Mercury
OSHA	2204	Carcinogens
OSHA	2225	Vinyl Chloride
OSHA	2248	Toluene Diisocyanate
OSHA	2239	Beryllium

III. CHEMICALS

REFERENCE PAGE FOR HANDLING CHEMICALS

1. Do you have any of the known Carcinogens in your laboratory? For a list of the recognized carcinogens see page 25.

2. Chemistry laboratories may also contain biological poisons such as Mercury, Metals and their salts, Organic Solvents, and some gases. For discussion of the dangers inherent in each of these materials see page 26.

3. Many chemicals should not be stored near other types of chemicals. For a list of Incompatible chemicals see page 27.

4. Some chemicals present a fire or explosion hazard. For guidelines on what to use in the case of an emergency see pages 29, 30, and 33. For a list of of the explosive danger of many chemicals see Appendix F, page 85.

5. The proper labeling of chemicals, especially for safety information, is very important. For a list of the information that the label should contain see page 35.

6. The proper storage of chemical acquires that appropriate containers be used and all areas clearly labeled. For guidelines on this topic and a list of containers see pages 36 and 37. For plastic containers see page 38.

7. Some chemistry experiments are very dangerous because of the nature of the materials or the procedure being used. The following are discussed in this section:

   Oxygen page 40
   Hydrogen page 41
   Halogens page 41
   Nitrogen and Nitrogen Compounds page 41
   Sulfur and Sulfur Compounds page 42
   Phosphorous and Phosphorous Compounds page 42
   Plastics page 42
   Soap Making page 42
   Thermite page 43
   Perchloric Acid page 43
   Test tubes page 43

8. Spills are very common in a chemistry laboratory. They should not be handled casually, but should be treated with the appropriate material for each class of substance. For guidelines on how to treat different types of materials, see page 44. For equipment needed in order to clean up spills see page 45.

9. No chemistry experiment can be considered completed until the laboratory has been properly cleaned up. For guidelines on the safe disposal of different types of material see page 47.

III. CHEMICALS

Introduction

Is the high school science classroom hazardous to the students' health? It can be. Hazardous, including carcinogenic, chemicals have been found on some laboratory shelves, and science supervisors and instructors are becoming increasingly aware of the potential health threat of performing certain experiments and using certain chemicals or chemical combinations.

Danger to health, including potential lung disease, should be considered, along with traditional safety warnings of fire, explosion, and spillage in the science classroom. Here is some of the reasoning behind this statement:

> An increasing number of diseases are found to be derived from exposure to certain chemicals and substances, exposures that began, and often ended, years and sometimes decades before the onset of symptoms. School health officials and science teachers have a responsibility to check out the new information on potential dangers of substances used in the science classroom or laboratory.
>
> Many students who study Biology or Chemistry in high school make a career of laboratory work. A healthy respect for the potential exposures in this field can lead to a lifetime of good work habits and perhaps a longer, healthier life.
>
> Teachers and laboratory assistants are exposed to potential toxins more frequently than are students and for longer periods of time.
>
> Schools have been held liable by the courts for accidents resulting from negligence in safety procedures. If health problems are eventually traced back to classroom exposure, the schools may again be liable.
>
> The federally administered Occupational Safety and Health Administration (OSHA) does not have jurisdiction over public schools, but OSHA can investigate private institutions for violation of health and safety standards. In many of the 22 states where OSHA is administered at the state level, coverage is broader and may include public employees, making schools subject to inspection and penalties.[1]

A. What Can Be Done?

So what's a science teacher to do? One thing science teachers and their supervisors are beginning to do is to discuss the problem. A conference, Health Hazards in the Science Classroom, sponsored by the American Lung Association of Nassau-Suffolk (Long Island, N.Y.) and the Nassau County Board of Cooperative Educational Services, provided an introduction to the problems. Susan M. Daum, M.D., and Jeanne M. Stellman, Ph.D., co-authors of Work Is Dangerous to Your Health*, were the main resource people.

---

[1] Trenk, Barbara S., "Health Hazards in the Classroom" from American Lung Association Bulletin, V. 36: #4, 1977.

EDUCATE YOURSELF AND DEVELOP A SAFETY PROGRAM!

B. CHEMICAL HAZARDS

The CHEMICAL HAZARDS that any science teacher may be faced with will probably fall into one of the following categories:

1. The presence of cancer producing agents (carcinogens).
2. The casual use of biological poisons.
3. The improper contact or storage of incompatible materials.
4. The accidental explosion or fire.

1. CARCINOGENS on laboratory shelves

Experts agree that certain chemicals have no place on the shelves of a high school laboratory. Many state education or OSHA departments have ordered that all of the 16 known carcinogens (see Figure 1) be removed from high school and college classroom shelves. These are substances for which the recommended exposure level is essentially zero.

A survey by Kentucky Labor Department officials found that 90% of the 41 four-year colleges and universities in that state had one or more of these cancer-causing chemicals, as did 5% of the high schools, according to a report in the September 1976 Journal of College Science Teaching.

Figure 1

OSHA has prepared regulatory standards for the following carcinogens:

4-Nitrobiphenyl (4-NBP)
Alpha-Naphthylamine (1-NA)
4, 4'-Methylene bis (2-chloroaniline) (MOCA)
Methyl chloromethyl ether (CMME)
3, 3' Dichlorobenzidine (and its salts)
Bis chloromethyl ether (BCME)
Beta-Naphthylamine (2-NA)
Benzidine
4-Aminodiphenyl
Ethyleneimine (EL)
Beta-Propiolactone (BPL)
2-Acetylaminofluorene
4-Dimethylaminoazobenzene (DAB)
N-N' Nitrosodimethylamine (DMN)
Vinyl cholride
Asbestos

A list of alternate chemical names, prepared by Dr. J.B. Block, is available from your lung association.

---

*Published by Vintage Books, a division of Random House.

36

School personnel wishing to survey their districts for the presence or use of these substances should be aware of two things, advises J. Bradford Block, M.D., medical consultant to Kentucky's Department of Labor. The first is that each of the 16 carcinogens is known by a variety of names, so that even the knowledgeable chemistry teacher may need a complete listing to do a thorough search of the science department shelves. (Dr. Block's long list of alternate names appeared in the Journal of College Science Teaching article mentioned above. Reprints are available as indicated in Figure 1.) The second consideration is that improperly packaged and disposed of carcinogens may be even more dangerous than they were on the schoolroom shelves. It is recommended that school officials consult their local health department before disposing of such materials.

2. Biological Poisons

a. Mercury is a cellular poison, (2) primarily affecting the renal and nervous systems and can enter the body by ingestion, absorption through the skin or inhalation in the form of vapor. Symptoms of mercury poisoning are irritability, inflammation of mouth and gums, muscular tremors, psychic disturbance, headache and loss of memory. In the laboratory situation, the inhalation route causes the greatest concern. Mercury can vaporize at room temperature from open pools of mercury or from the tiny globules of mercury that remain in cracks of the floor after spills occur (broken thermometers). Every attempt should be made to keep the lab free of mercury, and to have older laboratories checked professionally to be sure mercury levels are kept to the minimum (0.1 mg/m^3 of air). Spills can be cleaned up with a vacuum flash-hose (with a glass tip) apparatus connected to a vacuum pump or aspirator. Activated alumina (Aluminum oxide) can be used as a sweeping compound.

b. Heavy Metals and their Salts: arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), manganese (Mn), selenium (Se), and vanadium (V)

Use extreme caution with these elements and their salts as they are biological poisons. Students should be trained to read the labels on chemical bottles, particularly the warnings and what to do in case of accidental exposure. Further, good housekeeping procedures, cleaning up lab benches, and washing hands before leaving the laboratory, should be emphasized when such materials are being used. Students should never be allowed to draw up such solutions by mouth with pipettes. Use suction bulbs, droppers or burets.

c. Organic Solvents such as benzene (C_6H_6), carbon tetrachloride (CCl_4), carbon disulfide (CS_2), dimethyl ether $(CH_3)_2O$, have short term effects on living tissue such as liver and nervous tissue, acting to kill cells. Skin contact and vapor inhalation should be avoided. (3) Long term effects may be in the form of cancers.

---

(2) Laboratory Safety, Vol.II, No. 1, January 1966, Department of Environmental Health and Safety.

(3) Laboratory Safety, Vol.I, No. 6, June 1965.

37

d. Common Gases such as nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), hydrogen sulfide (H_2S), halogens (F_2, Cl_2, Br_2, I_2), and ozone (O_3) formed from reactions being carried out by students are toxic (4, 5, 6) and should be carried out in a hood. If the lab equipment does not ventilate fast enough to carry away the fumes, don't do the experiments. Early physical symptoms of the effects of these gases are headaches, irritated throat and nasal membranes and/or coughing. Edemas appear some 72 hours later if toxic levels are high enough and death may follow.

3. Incompatible Materials

Many substances may react violently when they come in contact with each other. It is recommended that such INCOMPATIBLE MATERIALS are not stored together. A list of common chemicals that should not be stored near each other is given below. More extensive lists may be found in the references that follow (1, 2, 3).

PARTIAL LIST OF INCOMPATIBLE CHEMICALS*

Substances in the right-hand column should be stored and handled so they cannot possibly contact corresponding substances in the left-hand column.

Alkaline and alkaline earth metals, such as sodium, potassium, cesium, lithium, magnesium, clacium, aluminum	Carbon dioxide, carbon tetrachloride, and other chlorinated hydrocarbons. (Also prohibit water, foam, and dry chemical on fires involving these metals.)
Acetic acid	Chromic acid, nitric acid, hydroxylcontaining compounds, ethylene glycol, perchloric acid, peroxides, and permaganates.
Acetone	Concentrated nitric and sulfuric acid mixtures.
Acetylene	Chlorine, bromine, copper, silver, fluorine, and mercury.
Ammonia (anhyd.)	Mercury, chlorine, calcium hypochlorite, iodine, bromine, and hydrogen fluoride.
Ammonium nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organics or combustibles.
Aniline	Nitric acid, hydrogen peroxide.
Bromine	Ammonium, acetylene, butadiene, butane and other petroleum gases, sodium carbide, turpentine, benzene, and finely divided metals.
Calcium carbide	Water (see also acetylene).

---

(4) Laboratory Safety Newsletter: Vol.II, No. 7, September, 1967.
(5) Laboratory Safety Newsletter: Vol.II, No. 6, June, 1966.
(6) Laboratory Safety Newsletter: Vol.II, No. 8, August, 1966.
Department of Environmental Health and Safety
University of Michigan Health Services.

Calcium oxide	Water.
Carbon, activated	Calcium hypochlorite.
Copper	Acetylene, hydrogen peroxide.
Chlorates	Ammonium salts, acids, metal powders, sulfur, finely divided organics or combustibles.
Chromic acid	Acetic acid, naphthalene, camphor, glycerine, turpentine, alcohol, and other flammable liquids.
Chlorine	Ammonia, acetylene, butadiene, butane and other petroleum gases, hydrogen, sodium carbide, turpentine, benzene, and finely divided metals.
Chlorine dioxide	Ammonia, methane, phosphine, and hydrogen sulfide.
Fluorine	Isolate from everything.
Hydrocyanic acid	Nitric acid, alkalies.
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, any flammable liquid, combustible materials, aniline, nitromethane, caustic soda and other strong alkalies.
Hydrofluoric acid, anhyd. (Hydrogen fluoride)	Ammonia, aqueous or anhydrous.
Hydrogen sulfide	Fuming nitric acid, oxidizing gases.
Hydrocarbons (benzene, butane, propane, gasoline, turpentine, etc.)	Fluorine, chlorine, bromine, chromic acid, sodium peroxide.
Iodine	Acetylene, ammonia (anhyd. or aqueous).
Mercury	Acetylene, fulminic acid, ammonia.
Nitric acid (conc.)	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, and nitritable substances.
Nitroparaffins	Inorganic bases.
Oxygen	Oils, grease, hydrogen, flammable liquids, solids or gases.
Oxalic acid	Silver, mercury.
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, oils.

Peroxides, organic	Acids (organic or mineral); avoid friction.
Phosphorus (white)	Air, oxygen.
Potassium Chlorate	Acids (see also chlorate).
Potassium perchlorates	Acids (see also perchloric acid).
Potassium permanganate	Glycerine, ethylene glycol, benzaldehyde, sulfuric acid.
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds.
Sodium	See alkaline metals (above).
Sodium nitrate	Ammonium nitrate and other ammonium salts.
Sodium oxide	Water.
Sodium peroxide	Any oxidizable substance, such as ethanol, methanol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerine, ethylene glycol, ethyl acetate, methyl acetate, and furfurial.
Sulfuric acid	Chlorates, perchlorates, permanganates.
Zirconium	Prohibit water, carbon tetrachloride foam, and dry chemical on zirconium fires.

*Based on Dangerous Chemicals Code, 1951 Edition, pp. 19-20, Bureau of Fire Prevention, City of Los Angeles, Fire Department, published by Parker & Company, Los Angeles 13, California.

4. Fire Hazards and Explosions

a. Fire Hazards

The science classroom by its very nature is a potential fire hazard. The physical plant, by having both fuel sources and an electrical supply for electrical equipment has far more explosive potential than other classrooms with just the electrical source.

The contents of a classroom (the materials or chemicals that are in common use), in many cases, are flammable or will readily react with other materials to produce a fire. The potential is there, within the science classroom, for any class of fire A, B or C.

Class of Fire: *	Requires:
A - wood, paper, rubber, plastics B - flammable liquids, gases, greases C - electrical equipment	Multi Purpose ABC Type fire extinguisher.
Burning Hair, clothing, or person	Use water or fire blanket. DO NOT USE CO_2

*See reference, page 34, or Appendix F.

Possibly the most common types of accidental fires in the science laboratory are those of clothes and hair resulting from students leaning over too close to an open flame or passing their arm through an open flame. Water would be the most effective remedy in both cases. A fire blanket, if readily available, can be used. DO NOT USE a CO_2 fire extinguisher on an individual. The blast from the CO_2 could aid in spreading the fire and could, conceiveably, cause frostbite, thereby compounding the burn.

You should be fully aware of the potential hazards involved with any chemical or material being used by the students. Certain physical properties such as flash point of a substance that is going to be heated should be known. For example, the flash point of ethyl alcohol is 55°F (13°C). This means a spark or open flame brought near the surface of the alcohol at room temperature will ignite it immediately.

FLASH POINTS of some of the more common substances are given below, in F.

Acetaldehyde	-36°F	Ethyl acetate	24°F
Benzene	12°	Ethyl alcohol	55°
Butylalcohol	84°	Ethyl chloride	-58°
Carbon disulfide	-22°	Hexane	-7°
Cellulose nitrate	55°	Methyl alcohol	52°
Cyclohexane	-4°	Toluene	40°
Ether (diethyl)	-49°	Xylene	81°

A spill of any one of the above is a definite fire hazard and students should be removed from the vicinity immediately until the spill has been cleaned up.

References:

1. Los Angeles Fire Department, "Dangerous Chemicals Code", 1951, Parker & Son, Inc., Los Angeles, California.

2. Safety Education and Training Division, Bureau of Safety and Regulation, Michigan Department of Labor, 300 E. Michigan Avenue, Lansing, MI 48926.

3. Manufacturing Chemists Association-
"Chemical Safety Data Sheets"
"Safety Guides"
"Chem-Card Manual"
1825 Connecticut Avenue, Washington D.C. 20009

b. Explosive Hazards

Any compound or mixture which may be potentially explosive should be regarded with suspicion and handled with more than usual care. When any doubt exists about a system, its potential energy (or potential explosion energy) can often be calculated.

The hazards involved in working with a potentially explosive system are directly proportional to the speed with which the energy is released and to the amount of gas evolved. Thus, since reaction rates are more difficult to predict than potential energy content, caution is always necessary. The volume of gas can, of course, be readily calculated if this energy is known. The most accurate values are obtained when all heats of formation involved are known, but if they are not, they can be readily obtained with a good degree of reliability from Pauling's bond-strength values (by Kharasch's method for calculation of heat of combustion, etc.), or estimated by analogy with sufficient precision. In making the calculation when data are not available for the distribution of elements in the products, one should assume a reasonable reaction to yield the most exothermic products.

Despite the ability to calculate a hazard index, it is most helpful to have structural and other indications to suggest properties and possible hazards. Certain groups, when present in a molecule, can either confer or enhance explosive properties and may increase sensitivity. For the radicals listed below, the ability to directly produce explosive power diminishes in passing from Group 1 to Group 2.

In Group 1a, the mixing of radicals in a molecule may have effects other than those expected from additivity alone. For example, nitrates are acid sensitive and are also sensitive to strongly basic groups. Thus, a molecule is immediately suspect if it contains a nitrate group and either (1) a primary nitramine, primary aliphatic nitro, phenolic OH, carboxyl, or other acid group; or (2) an amino, hydrazine, basic ammonia, or similar basic group. In general, the potential hazard of a molecule increases with the number of radicals and especially with their variety. This is also true when an electronegative element such as Cl is present on the same atom as a Group 1 radical; thus, the combination $-N(Cl)NO_2$ has been found to be particularly unstable and sensitive. In the case of organic salts, the hazard increases with the acid radical, as follows: nitrates, perchlorates, iodates, bromates, and chlorates. Chlorites are difficult to classify, but the lower oxy-acids of clorine are quite reactive, and clorites should be considered dangerous, especially when in contact with organic matter. In any case, extreme caution should be observed when mixing any of these salts with organic matter and/or acids (even dilute acids) because halogen oxides may be released.

In Group 1b are listed radicals which will make a molecule both unstable and exceedingly sensitive to impact. This is especially true because even as little as a milligram of such a material (e.g. lead azide) will detonate and release energy and gaseous products with amazing rapidity.

Many of the compounds containing such groups are too dangerous to handle (e.g., phenyl diazosulfide has an explosion temperature of 25°C). The nitroso radical is the least hazardous to those in Group 1b, but its presence cannot be ignored.

The presence of groups with specific acid ($-NH-NO_2$, $-COOH$), base ($-NH-NH-$), reactive (-CHO), oxidizing ($-ClO_3$), reducing (-NO), or similar group characteristics cannot be ignored. In general, these usually increase sensitivity and decrease stability. The presence of phenolic groups may lead to a hazard through metal salt formation (especially heavy metals), while under certain conditions the presence of ether and carbonyl groups may lead to the formation of very dangerous peroxides.

Mixtures of organic materials with inorganic salts of the Group 1b acids are quite hazardous, as would be expected from the discussion of organic salts, and some are extremely sensitive to friction and impact. Besides the trends noted above, unsaturated or reactive organics present the greatest hazards, e.g., acetylenic derivatives, sulfur compounds, etc. The acids themselves are infinitely more reactive than the salts, and their liberation, even from salt mixtures, often leads to spontaneous explosion. Where it is possible that acidity may develop in such mixtures, fine sodium bicarbonate or chalk should be incorporated in the mixture.

Group 1 - Radicals which confer explosive properties directly (contain phosphores or phosphoric groups)

a. Result in high potential energy

$-ONO_2$	Nitrate
$-NH-NO_2$	Primary nitramine
$=N-NO_2$	Secondary nitramine
$R-NO_2$	Aliphatic nitro compound
$AR-NO_2$	Aromatic nitro compound
Salts, organic	Perchlorates, chlorates, nitrates, bromates, chlorites, and iodates

b. Result in relatively low potential energy

$-N_3$	Azide
-NO	Nitroso
-N=N-	Diazo
-N=N-S-N=N-	Diazo sulfide
-O-O-	Peroxide
=N-X	Halamines (X=F, Cl, Br, I)
-C=C-	Acetylenes
-O-O-O-	Ozonides

Group 2 - Radicals which enhance potential energy

-CN	Nitrile
=N-OH	Oxime
-O-	Ether

In considering the above, it might be noted that, other factors remaining constant, as the oxygen balance approaches zero, energy content increases while sensitivity and stability decrease. A list of Potentially Explosive Substances may be found in Appendix F.

REFERENCE: IN THE EVENT OF AN EXPLOSION

Everyone should:

- extinguish all burners and heaters
- stop adding reagents
- assist injured and evacuate room immediately since toxic gases may be present
- give necessary first aid

Educate your students as to what to do in case of fire such as:

1. Pull the closest alarm signal button.
2. Turn off the central cut-off for the fuel supply.
3. Pull the circuit breakers for electrical circuits for the room.

ESTABLISH YOUR OWN PROCEDURE AND PRACTICE IT EVERY TIME THERE IS A SCHOOL-WIDE FIRE DRILL.

REFERENCE: PUTTING OUT FIRES

1. For A, B, C, Fires-Use proper extinguisher.

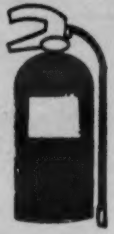
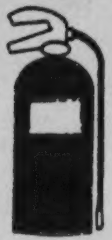
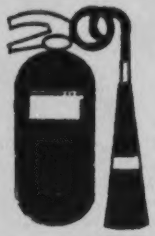
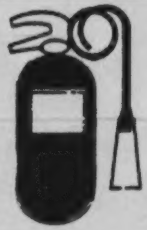
2. For Mg/Al fires - use Pyrene G-1 Extinguisher
   Ansul Met -L-X

3. For hair, clothing, person - USE WATER
   USE FIRE BLANKET

See following page for type of extinguisher to use on which type of fire.

44

KNOW YOUR
FIRE EXTINGUISHERS

	WATER TYPE	A	Ordinary Combustible Fires
	DRY CHEMICAL	B	Flammable Liquid Fires (Gas and Grease)
	CO^2 TYPE (Plastic Horn Only)	C	Electrical Equipment Fires
	MULTI-PURPOSE DRY CHEMICAL TYPE	A B C	For Ordinary Combustible Fires Flammable Liquid Fires Electrical Equipment Fires
	DRY POWDER TYPE	D	For Combustible Metal Fires (These Metals In Finely Divided Form Need Special Fire Attack)

USE ONLY UNDERWRITERS APPROVED EXTINGUISHERS

LABELING OF CHEMICALS

Introduction

The labeling of chemical containers is absolutely essential to safe operations. The label should be complete giving all of the necessary information needed for any emergency situation:

The label should contain the following information:

1. Name of chemical and concentration if it's in liquid form. (Dilution of a chemical will decrease some of the potential hazards).
2. Degree of hazard. This is indicated by the use of an appropriate signal word, DANGER, WARNING, or CAUTION.
3. Statement of hazard. A word or two to indicate each type of hazard. Examples illustrating this would be POISON, CAUSES BURNS, EXTREMELY FLAMMABLE, VAPOR HARMFUL, EXPLOSIVE.
4. Precautionary measures. Precautionary measures are intended to be instructions which describe how users can avoid injury from the hazards given in item 3 above.
   Example: Use only with adequate ventilation. Do not get in eyes, on skin or clothing.
5. Instructions in case of contact or exposure. This is the treatment that is to be given immediately to minimize injury if accidental exposure should occur.
   Example: In case of contact immediately flush with water. For eyes, rinse freely for 15 minutes, get medical attention.
6. Shelf-life/date of acquisition. Certain chemicals decompose over a period of time so the container may no longer contain what the label says.
   Example: Ethers may oxidize over a period of time to form explosive peroxides.

References

A Condensed Laboratory Handbook, E.J. duPont de Nemours and Co., Inc., Wilmington, Delaware, 19898.

Chem-Card Manual, Manufacturing Chemists Association, 1825 Connecticut Avenue, N.W., Washington, D.C. 20009.

Department of Labor, Safety Standards, Part 16, Labeling of Hazardous Substances.

Emergency Procedures for Dangerous Materials (chart), Science Related Materials, Inc., Jonesville, Wisconsin, 53545.

Guide to Precautionary Labeling of Hazardous Chemicals, Manufacturing Chemists Association, 1825 Connecticut Avenue, N.W., Washington D.C. 20009.

D. CHEMICAL STORAGE

Introduction

The potential for accidents and unsafe teaching conditions may be reduced through proper storage, handling, and disposal of chemicals in the laboratory. In this section we will deal with considerations a chemistry teacher must make regarding the storage of chemicals. Improper storage of chemicals may at the very least lead to waste through interaction of incompatible chemicals making them unfit for use, or at the other extreme cause an explosion and/or fire which could endanger both students and staff. It is therefore important that the following be carefully considered in your laboratory organization plans. For example, it is an unsafe practice to store chemicals on the floor. Cupboards for storage are highly recommended.

1. Cupboards or CABINETS should be CLEARLY LABELED for their contents as well as to the types of fire fighting materials that can be used in case of fire (e.g., water, CO_2, sand, other). Appropriate fire extinguishers used for various types of stored materials are shown previously, page 34.

2. A list of Incompatible Substances may be found on page 27. Such materials should not come in contact with each other and therefore, should not be stored together.

3. A partial list of recommended STORAGE CONTAINERS for common laboratory chemicals is shown on the next page.

4. FLAMMABLE LIQUIDS (acetone, alcohols, alkanes, etc.)

   a. Should be stored in metal safety cans with spring loaded covers.
   b. Should be stored in metal cabinets and not combustible wood cabinets or cupboards.
   c. Recommended - Purchase only the amounts actually needed. Do not try to build up an inventory.
   d. The maximum amount of flammable liquids that can be stored outside of a fireproof storage place is 1 gallon total.
   e. If a refrigerator is used for chemical storage, it must be an explosion proof model.

5. PLASTIC STORAGE CONTAINERS come in many types. A chart of "Resistance Properties of Plastic Materials" is included for storage containers that are appropriate for various classes of substances on page 38.

EXPLOSIVES

Picric Acid	Glass Stoppered Bottle (G.S.B.)
Collodions	
Carbon Bisulphide	G.S.B.

*FLAMMABLE LIQUIDS

Crude Petroleum	Tin Can
Benzine, Benzol or Naphtha	Tin Can
Coal Tar	Tin Can
Coal Tar Oils	Tin Can
Wood Creosote	Tin Can
Ether, Ethyl	Tin Can
Varnishes, Lacquers	Tin Can
Acetone	Tin Can
Alcohol, Ethyl	Tin Can
Alcohol, denatured	Tin Can
Alcohol, Methyl	Tin Can
Aldehyde, Ethyl	G.S.B.
Amyl acetate	G.S.B.
Amyl Alcohol	G.S.B.
Kerosene	Tin Can or G.S.B.
Nitrobenzol	Tin Can
Turpentine	Tin Can
Toluol or Toluene	Tin Can
Xylol or Xylene	Tin Can
Essential oils	G.S.B.
Glycerine	G.S.B.

COMBUSTIBLE SUBSTANCES

Phosphorus white	Under water in glass bottle surrounded with sand
Phosphorus red	G.S.B.
Sulphur	Tin Can
Metallic magnesium (strip and powder)	G.S.B.
Camphor	G.S.B.
Rosin	G.S.B.
Pitch	Tin Can
Tar	Tin Can
Venice turpentine	G.S.B.
Burgundy pitch	G.S.B.
Naphthalene	G.S.B.
Shellac	G.S.B.
Resins Balsams	Tin Can
Pulverized Charcoal	Tin Can
Lampblack	Tin Can
Cotton absorbent	Paper box
Cotton batting	Paper box
Zinc Dust	G.S.B.

DANGEROUSLY CORROSIVE CHEMICALS

Glacial Acetic Acid	G.S.B.
Hydrofluoric Acid	Wax bottle in a container of kaolin
Hydrochloric acid	G.S.B. (6 lbs per bottle)
Sulphuric adic	G.S.B. (9 lbs each bottle)
Phenol	G.S.B.
Sodium hydroxide	G.S.B.
Potassium hydroxide	G.S.B.
Acid chromic	G.S.B.
Acid nitric	G.S.B.

PEROXIDES AND OTHER OXIDIZING AGENTS

Hydrogen peroxide	G.S.B.
Sodium peroxide	Tin box
Potassium peroxide	G.S.B.
Calcium peroxide	G.S.B.
Barium peroxide	G.S.B.
Potassium chlorate	G.S.B. or tin can
Sodium Chlorate	G.S.B. or tin can
Barium Chlorate	G.S.B.
Other metallic chlorates	G.S.B.
Potassium Permanganate	G.S.B.
Sodium permanganate	G.S.B.
Other metallic permanganate	G.S.B.
Bismuth Subnitrate	G.S.B.
Barium nitrate	G.S.B.
Strontium nitrate	G.S.B.
Cobalt nitrate	G.S.B.
Iron nitrate	G.S.B.
Mercury nitrate	G.S.B.
Potassium nitrate	G.S.B. or tin can
Silver nitrate	G.S.B. (brown bottle)
Sodium nitrate	G.S.B. or tin can
Other metallic nitrates	G.S.B.

SUBSTANCES MADE DANGEROUS BY CONTACT WITH WATER

Calcium Carbide	G.S.B.
Metallic Potassium	Under kerosene in bottle in sand
Metallic Sodium	Under kerosene in bottle embedded in sand.
Quicklime	Tin Can
Sulfuric acid	G.S.B.

*Note: When possible, safety cans should be used for storage and dispensing of flammable liquids.

Safety Education & Training Division, Bureau of Safety & Regulation, Michigan Dept. of Labor, 300 E. Michigan, Lansing 48926

Science Advisory Committee, Curriculum Division, Michigan Department of Education, Lansing, Michigan 48902

RESISTANCE PROPERTIES OF PLASTIC MATERIALS

The chart below should be taken as a general guide only. It states that, for most compounds of the class indicated, the specific material is rated either Excellent, Good, Fair or Not Recommended.

Because so many factors can affect the chemical resistance of a given product, it is recommended that you test under your own conditions if any doubt exists.

The combination of compounds of two or more classes may cause an undesirable chemical effect. Other factors affecting chemical resistance include temperature, pressure and other stresses, length of exposure, and concentration of the chemical. As the maximum useful temperature of the plastic is approached, resistance to attack decreases.

CHEMICAL RESISTANCE CHART

(E)	Excellent. Long exposures (up to one year) at room temperature have no effect.
(G)	Good. Short exposures (less then 24 hours) at room temperature cause no damage.
(F)	Fair. Short exposures at room temperature cause little or no damage under unstressed conditions.
(N)	Not recommended. Short exposures may cause permanent damage.

Class of Substance	Conventional Polyethylene	Linear Polyethylene	Polyallomer	Polypropylene	Teflon FEP	Polycarbonate	General Purpose Polystyrene	Styrene-Acryloni-	Polyvinly Chloride
Acids, Inorganic	E	E	E	E	E	E	N	G	G
Acids, Organic	G	E	E	E	E	F	G	G	G
Alcohols	E	E	E	E	E	G	G	G	G
Aldehydes	G	G	G	G	E	F	N	N	N
Amines	G	G	G	G	E	N	G	G	N
Bases	E	E	E	E	E	N	G	G	G
Dimethyl Sulfoxide (DMSO)	E	E	E	E	E	N	N	N	N
Esters	G	G	G	G	E	N	N	N	N
Ethers	G	G	G	G	E	G	F	G	N
Foods	E	E	E	E	E	E	E	G	G
Glycols	G	E	E	E	E	G	G	G	F
Hydrocarbons, aliphatic	G	G	G	G	E	F	N	F	G
Hydrocarbons, aromatic	G	G	G	G	E	N	N	N	N
Hydrocarbons, halogenated	G	G	G	G	E	N	N	N	N
Ketones	G	G	G	G	E	N	N	N	N
Mineral Oil	E	E	E	E	E	E	G	G	E
Oils, essential	G	G	G	G	E	F	N	F	N
Oils, lubricating	G	E	E	E	E	G	G	G	E
Oils, vegetable	E	E	E	E	E	E	G	E	E
Proteins, unhydrolyzed	E	E	E	E	E	E	G	E	G

Class of Substance	Conventional Polyethylene	Linear Polyethylene	Polyallomar	Polypropylene	Teflon FEP	Polycarbonate	General Purpose Polystyrene	Styrene-Acrylonitrile	Polyvinyl Chloride
Salts	E	E	E	E	E	E	E	E	E
Silicones	G	E	E	E	E	E	G	G	G
Water	E	E	E	E	E	E	E	E	F
PHYSICAL PROPERTIES									
Temperature Limit, C	80	120	130	135	205	135	70	95	70
Specific Gravity	0.92	0.95	0.90	0.90	2.15	1.20	1.07	1.07	1.34
Tensile Strength, psi	2000	4000	2900	5000	3000	8000	6000	11,000	6500
Brittleness, Temp.- C	-100	-100	-40	0	-270	-135	*	-25	-30
Water Absorption, %	0.01	0.01	0.02	0.02	0.01	0.35	0.05	0.23	0.06
Flexibility	excellent	rigid	slight	rigid	excellent	rigid	rigid	rigid	rigid
Transparency	translucent	opaque	translucent	translucent	transparent	clear	clear	clear	clear
Relative O_2 permeability (Arbitrary scale for comparison purposes only)	0.40	0.08	0.02	0.11	0.59	0.15	0.11	0.03	0.01
Autoclavable	No	With Caution	Yes	Yes	Yes	Yes	No	No	No

*Normally somewhat brittle at room temperatures.

Courtesy, Nagle Company, Rochester, New York 14602

Safety Education & Training Division, Bureau of Safety & Regulation, Mich. Dept. of Labor, 300 E. Michigan, Lansing 48926

Science Advisory Committee, Curriculum Division, Michigan Department of Education, Lansing, Michigan 48902

E. HANDLING CHEMICALS DURING EXPERIMENTS (1)

1. Procedures

The inherent dangers present in all procedures in chemistry provide the teacher with opportunities not only to teach safety by word but also by constant example. Students are to be warned of all potential dangers in every experiment and to be aware of them while doing each procedure; it may be well to have the student underline these cautions or to indicate them in his own words at the top of each sheet. Students must be taught respect, rather than fear, for the reagents that they will use throughout the course. Each student should be prepared to employ appropriate first aid measures should an accident occur. Not only should students be required to wear protective equipment, but the instructor should set the example by donning these safety devices whenever a laboratory experiment or demonstration is undertaken.

The following recommendations are suggested in the performance of experiments and demonstrations in chemistry and/or general science.

2. The Laboratory Preparation of Oxygen

Students should be instructed to remove the delivery tube from the pneumatic trough before removing the heat. Otherwise, water will be drawn up into the generator and will cause an explosion. Students should also be instructed not to reheat the generator after allowing it to cool; this would cause an explosion of the oxygen that has collected within the generator. Prior to the laboratory period, the teacher should check the oxidizing agent for any contamination since the presence of any organic material would cause a violent explosion. Exercise precautions that charcoal has not been substituted for manganese dioxide.

Caution students to see that the carbon formed in using wooden test splints does not fall into hot mixture of manganese dioxide and potassium chlorate. Should this happen, heating must be stopped immediately.

When sodium peroxide is used in the preparation of oxygen, it should be supplied to the students in a dry flask. In adding water, control the rate of flow with a dropping funnel. Avoid skin contact with the moist sodium peroxide. After reduction, the residue contains caustic alkali. To avoid cracking of the generator, due to the heat that is produced, it is best to use an Erlinmeyer or Florence Flask of Pyrex glass. Be sure that no active sodium peroxide is left in contact with easily flammable substances. It is suggested that this method for preparation not be used with students. It may be noted here that the tablets called Oxone, sold in some supply catalogs, are merely sodium peroxide and are extremely dangerous.

Manganese dioxide obtained from dry cells contains powdered carbon and should never be used in the preparation of oxygen. When heating silver oxide, lead dioxide, potassium permanganate, red lead and mercuric oxide, the hood should be used. Oxygen can be prepared from peroxides. By adding a few crystals of potassium permanganate to a 6 per cent hydrogen peroxide solution, we can get an excellent supply of oxygen. If too much $KMNO_4$ is added, the evolution of gas is so rapid it cannot be collected, but no danger will result. This method has almost no danger since no heating is required. (Hydrogen peroxide, once removed from the original container, should not be returned because of the risk of contamination).

3. The Laboratory Preparation of Hydrogen

The students should be instructed to check the tubing carefully to see that it is free of foreign material, especially the lower end of the thistle tube so that a free movement of gas may pass, should pressure build up in the generator. Only small amounts of the evolved gas should be tested for purity, in no case should the gas coming directly from the generator be tested. As an added precaution, the generator should be wrapped in a wet towel; this will arrest flying glass should there be an explosion. Any type of automatic generator or Kipp generator should be equipped with a safety device. These are usually available through science supply houses or they may be constructed by soldering a piece of fine wire mesh over the end of a piece of brass tubing that fits into the rubber tubing. This will prevent a flashback of the flame into the generator which may cause an explosion. When preparing hydrogen by placing the active metals: sodium, potassium and calcium in water, use very small amounts of the metal to avoid dangerous spattering.

4. The Laboratory Preparation of the Halogens

Since the halogen vapors are toxic, do not inhale the fumes from any of the halogens; should such occur, inhale gently ammonium hydroxide or alcohol, either of which will counteract the fumes. The preparation of chlorine should be done only by the instructor and immediately after the needed samples have been collected, the contents of the generator should be flushed with water and the contents disposed of in the waste jar.

Bromine vapor which is poisonous and corrosive to the skin and mucous membranes should be collected under water and should be delivered in sealed capsules. Open stock should be stored in glass stoppered bottles sealed with paraffin. Iodine vapor is poisonous and should be prepared in small quantities. Hydorfluoric acid is dangerous in both gaseous and liquid form. DO NOT GENERATE HF.

5. Use of Nitrogen and Nitrogen Compounds

In the experiment demonstrating the solubility of ammonia gas that uses an ammonia fountain, make sure that a round-bottom, sturdily constructed flask is used since a partial vacuum results and a violent explosion may occur. Students should be especially warned about the danger of concentrated nitric acid and concentrated silver nitrate solutions on the skin. When preparing nitrogen by heating a mixture of sodium nitrate and ammonium chloride, warn students of the existing danger of an explosion if the substances are overheated. For this reason, this experiment should be performed as a demonstration. Nitrous oxide and nitrogen iodide preparations SHOULD NEVER BE attempted by students under any circumstances.

6. Use of Sulfur and Sulfur Compounds

Caution students about the danger of burns from molten sulfur. The burns from molten sulfur are painful and heal very slowly. When burning sulfur or producing sulfur-dioxide by any means in the laboratory, see that there is exceptionally good ventilation. Inhaled sulfur-dioxide fumes are irritating to the respiratory system and poisonous. It may be advisable to perform sulfur-dioxide experiments as demonstrations, if ventilation systems are inadequate. Warn students about the dangerous and poisonous nature of hydrogen sulfide. As this gas is mixed with air, it is explosive, and when inhaled will cause headache, nausea and dizziness. Students should be permitted to dilute concentrated sulfuric acid only under the close supervision of the teacher. Under no circumstances pour water into the acid. The heavier acid should be poured into the water very slowly and stirred continually during mixing. Warn students against contact with the skin since burns are severe. When sucrose is dehydrated by sulfuric acid, do not permit the students to handle either the carbon residue or the container. The spongy lump of carbon contains some occluded concentrated sulfuric acid. The container may be very warm and could cause a heat burn. THIS EXERCISE SHOULD BE CONDUCTED UNDER A FUME HOOD.

7. Use of Phosphorus and Phosphorus Compounds

STUDENTS SHOULD NEVER BE PERMITTED TO HANDLE WHITE PHOSPHOROUS. Red phosphorous should be substituted in all possible experiments.

In using a solution of phosphorous in carbon disulfide to demonstrate spontaneous combustion, great care must be exercised. Cover the solution with a layer of water and keep it in a small glass stoppered bottle stored in a metal container, the bottom of which is embedded in sand. The solution is used by inserting a medicine dropper below the water into the solution. The dropper, contaminated with the phosphorous, becomes a fire hazard. It should be stored in the same can as the solution and attached to the neck of the solution bottle with a wire holder.

Surfaces contaminated with phosphorous can be decontaminated by washing with a solution of copper sulfate. When demonstrating the explosive union of iodine with white phosphorous, use very small quantities of each and be sure that all residues are properly disposed of and decontaminated, to prevent fire. In the preparation of phosphine, the greatest care must be exercised to prevent an explosion. The generator will explode if air enters. STUDENTS MUST NEVER BE ALLOWED TO PREPARE PHOSPHINE.

8. Preparation of Plastics

In the preparation of plastics, the room should be well ventilated.

9. Soap Making

When making soap from fats and oils, and using lye (caustic potash), stir the mixture constantly to avoid spattering.

10. Thermite

This experiment is preferably one for a demonstration. Care must be taken in igniting the starting mixture of sodium peroxide and powdered magnesium. Be extremely cautious approaching a mixture which has apparently failed as it may still ignite. Be sure to partially immerse the crucible or container, in which the thermite reaction takes place, in a sand bath. This is a necessary fire precaution because of the intense heat that has developed. Be careful of the sodium peroxide. Dispose of all residues properly.

11. Special Precautions in the Use of Perchloric Acid

Perchloric acid is especially dangerous, because it explodes on contact with organic materials. Frequent inspections should be made to avoid perchloric accumulation in the blower system of the fume hood, with constant danger of explosion. Do not use perchloric acid around wooden benches or tables. Keep perchloric acid bottles on glass or ceramic trays having enough volume to hold all the acid in case the bottle breaks. PERSONNEL USING PERCHLORIC ACID SHOULD ALWAYS WEAR PROTECTIVE CLOTHING.

Discolored (therefore contaminated) acid should be disposed of immediately. Gently pour the acid into a heavy glass beaker or porcelain jar which contains at least ten volumes of cold water for each volume of acid. Mix gently and pour the beaker's contents down an acid sewer, flushing the sewer with large amounts of cold water.

12. Safe Handling of Test Tubes

A test tube has all of the firing ability of a small gun. The contents may be ejected with great force. For this reason, students should always direct the open mouth of a test tube being heated away from themselves and other students. Caution students to always dry the outside of the tube before heating it, and to avoid concentration of the flame at any one point. To do so would cause the tube to break, spilling the contents over the area.

Since many of these experiments involve the use of potentially hazardous substances, it might be helpful to show the film called Chemical Reactions (Modern Learning Aides), where each of these reactions are vividly demonstrated. The most severe hazards can be eliminated.

(1) Safety Science Seminar. "Safety in the Science Lab for Science Teachers: Instructors Manual". Safety Education and Training Division, Bureau of Safety and Regulation. Science Advisory Committee, Curriculum Division, Michigan Department of Education, (1970).

F. CHEMICAL SPILLS

Introduction

The instructor should always anticipate the possibility of having a chemical spill and have the necessary clean up materials already available. Further, students should know where such clean up materials are kept and what to do in case of spills.

1. In case of a spill alert all those who might be affected (depending on the composition of the spill).
2. If there is a fire hazard, extinguish all flames immediately and turn off any brush type motors. Shut down all experiments and vacate the room until decontaminated. See fire extinguisher types on page 34.
3. If there is no fire hazard use an absorbent material which will neutralize the liquids if possible.
    a. powdered sodium bicarbonate for acids.
    b. sodium thiosulfate solution (5-10%) for bromine.
    c. commercial absorbents, small particles of clay absorbents, or vermiculite.

   Use dustpan and brush to clean up absorbed materials. Wear rubber gloves. Clean contaminated area with soap and water and mop dry.

4. For the following: aromatic amines and nitro compounds, carbon disulfide, cyanides, nitriles, ethers and organic halides.
    a. flush with large amounts of water toward a drain.
    b. absorb liquids with paper towels or cloths which are disposed of in closed containers.
5. Mercury spills (2) should be immediately and very carefully cleaned up by using a trapped vacuum line attached to a tapered glass tube (micropipette). Cover small droplets in inaccessible spots with aluminum oxide to absorb globules or a small quantity of powdered sulfur to convert to the sulfide. Following sweeping, wash area with an acidic-detergent-water solution.

    1. MERCURY CLEAN-UP KITS may be obtained from the Department of Occupational Safety and Environmental Health, University of Michigan, Ann Arbor, MI.

    2. COMMERCIAL LAB SPILL KITS are currently available for approximately $50, that provide for the clean up of acids, alkalies, mercury, and flammable and toxic solvents. (e.g., Mallinckrodt)

   An excellent reference to keep in your lab for clean up and/or disposal of a wide variety of chemical substances is:

   "Laboratory Waste Disposal Manual", Manufacturing Chemists Association, 1825 Connecticut Avenue, N.W., Washington D.C. 20009.

   For example, minimum requirements for clean-up and disposal equipment are suggested by the MCA reference, and are listed on the following page.

DISPOSAL MATERIALS-MINIMUM REQUIREMENTS

(a) CHEMICALS

Acetone, waste (2 gal.)
Alcohol, butyl (2 gal.)
Alcohol, denatured (waste) (2 gal.)
*Ammonium hydroxide (concentrated, Reagent) (2 liters)
Ammonium hydroxide (6M) (4 liters)
Ammonium carbonate (2 x 1 lb.)
Benzene, waste (2 gal.)
Calcium hypochlorite (2 x lb.)
**Calcium polysulfide (2 x 1 liter)
Excelsior (box)
Fuels-scrap wood
    paper
    organic flammable solvents
Ferrous sulfate (2 x 1 lb.)
Ferrous sulfate, 30% (4 x 1 liter)
Ferric chloride (2 x 1 lb.)
Graphite powder (5 lb.)
Hydrochloric acid (concentrated, Reagent) (2 liters)
***Hydrochloric acid, (6M) (4 liters)
Hydrogen sulfide (small cylinder)
Ice, chipped
Kaolin (2 x 5 lb.)
Kaolin-Soda ash (50-50) (2 x 5 lb.)
Limestone, pulverized (2 x 5 lb.)
Litmus paper, red and blue (1 doz. vials each)
Marble chips (2 x 5 lb.)
Nitric acid (centrated, Reagent) (2 liters)
Paper boxes, waste
Potassium iodide, 10% (peroxide test)
Sand, dry (2 x 10 lb.)
Sand-Soda ash (90-10) (2 x 10 lb.)
Slaked lime (calcium hydroxide) (2 x 5 lb.)
Soap powder (6 x 1 lb.)
Soda ash (sodium carbonate) (2 x 5 lb.)
Soda ash-Slaked lime (50-50) (2 x 10 lb.)
Sodium bicarbonate (2 x 5 lb.)
Sodium hydroxide, 10% (4 liters)
Sodium hydroxide, 20% (4 liters)
Sodium bisulfite (5 lb.)
Sodium sulfite (5 lb.)
Sodium thiosulfate (hypo) (2 x 5 lb.)
Sulfur, sublimed (2 x 1 lb.)
Sulfuric acid (concentrated, Reagent) (2 liters)
****Sulfuric acid (3M) (4 liters)
Towels, paper (1 doz. rolls)
Vermiculite (or Oil-Dri, Sol-Speedi-Dri, etc.) (10 lb.)

*Requires approximately 400 ml. of concentrated reagent grade NH_4OH per liter of solution.

**Saturate one liter of concentrated lime water with hydrogen sulfide. Add excess sublimed sulfur. Shake.

***Requires 516 ml. of concentrated HCL per liter of solution.

****336 ml. of concentrated reagent H_2SO_4 per liter of solution.

(b) EQUIPMENT

Aspirator bottle (mercury collector) (2)
Atomizer spray bottle (2)
Beakers, 3 or 4 liter size (2)
Brush, hand (6)
Brush, small paint
Bucket, plastic (3 gal.)
Burners, Bunsen
Condenser, Liebig
Dish, evaporating, 12" (2)
Extinguisher (Class D fires) (30 lb. size)
Extinguisher (CO_2) (10 lb. size)
Flask, Distilling-1 liter (2)
Gloves, heavy work
Gloves, leather
Gloves, neoprene
Gloves, butyl rubber
Iron pan (for fume hood) (approx. 18" x 24")
Laboratory coat, cloth
Laboratory coat, plastic
Matting, open mesh, rubber, to fit sink
Mop and bucket
Pipettes 10 ml. (peroxide test) (4)
Respirator, canisters (1 of each)
Respirator (self-contained breathing apparatus)
Safety glasses or goggles (2 prs.)
Scoop, plastic
Shield, body
Shield, face, large and heavy, 0.050", to cover ears and neck
Spray jar (insecticide type), stainless steel
Suction pump (mercury collector)
Tank (oil drum, 55 gal.)
Tools-hammer
    pliers
    wrench, crescent
    screwdrivers
Water-vac

59

G. SAFE DISPOSAL OF CHEMICALS

Introduction

In the day to day operation of a high school chemistry laboratory wastes accumulate. Chemicals and broken glassware are just a few things that must be disposed of. It is important that waste disposal procedures be established and followed to insure that the laboratory continues to function in a safe manner (1, 2, 3). The following suggestions may prove to be beneficial.

1. Solid Materials: Solid materials should be disposed of in crockery storage jars with heavy protective crockery lids. No flammable substances, i.e., paper, should not be disposed of in these containers.

2. Acids: Most acids may be poured into water, then into the sink with additional large amounts of water.

3. Mercury: Keep mercury out of the sink. Mercury amalgamates with lead which will make the sink trap more susceptible to corrosion. Mercury should be stored in a closed non-metallic container. Spills can be cleaned up with a vacuum flask-hose (with a glass tip) apparatus, connected to a vacuum pump or respirator. Aluminium oxide can be used as a sweeping compound, or sulfur can be used to form the sulfide.

4. Most chemicals: Water soluble chemicals disposed of through the sewage system should be non-corrosive and non-toxic or in concentration well below the threshold limit. Water should be kept running during disposal to insure dilution. Check any of the references listed below for special cases.

5. Flammable Liquids: Pour substance onto or in a large pan containing sand, outdoors and ignite from a distance. Exceptions: nitroaromatics and azide salts.

6. Flammable Solids: Wrap in paper and incinerate. Amounts should be small and concentrations maintained well below threshold limits. Exceptions: nitroaromatics and azide salts.

7. Disposal of unknown substances: A major problem in any science classroom is the disposal of the contents of unlabeled containers.

   Unknown Liquids

   Check pH and flammability (add a drop to an evaporating dish and ignite carefully). If pH is high or low (alkaline or acid) and non flammable slowly add contents to a large volume of water and then pour slowly down the drain with the water tap wide open. Known acids or alkaline solutions may be disposed of in the same manner.

   If liquid is flammable pour into a large pan containing sand and ignite from a distance (outdoors).

60

Others

If there is any doubt concerning the disposal of any other materials or those described above, put the substance in a plastic container (test to be sure there will be no interaction between the container and the material) seal tightly and dispose of in a sanitary landfill. Professional "Chemical Waste Disposal" or "Waste Reduction and Disposal" companies may be found in the yellow pages.

References:

Several excellent References that you may wish to have in your laboratory are:

1. Laboratory Waste Disposal Manual, Manufacturing Chemists Association, 1825 Connecticut Avenue, N.W., Washington, D.C. 20009, 1970.

2. Steere, Norman V., Handbook of Laboratory Safety, Second Edition, Cleveland, Ohio: The Chemical Rubber Co., 1971.

3. Chemical Safety Slide Rule, National Safety Council, Stock No. 129.91, 425 N. Michigan Avenue, Chicago, Illinois 60611 (approx. $2.00).

61

REFERENCE PAGE FOR GASES, HEAT SOURCES, GLASS TUBING

1. Bottled gases must be handled with care in order to prevent an explosion. For guidelines see page 50.

2. Experiments that generate gases also create the danger of an explosion or possible toxicity. For a discussion of the dangers in different types of gases see pages 50-51.

3. Outside heat sources such as open flames, electrical heating, steam and heat resistant materials are used in many experiments. For a discussion of the safe use of each see pages 52 and 53.

4. Glass and plastic tubing are common laboratory items. Because they are used in almost every experiment they should be handled with care and not in a casual manner. For a discussion of the proper handling of these tubes see pages 54, 55, and 56.

5. In many laboratories plasticware has taken the place of glass. Plastics present their own unique hazards. For a discussion see page 56.

IV. HANDLING GASES

Introduction

If it is necessary to work with bottled gases in the chemistry laboratory, the following considerations are recommended. In gas generation experiments even a relatively harmless gas may cause serious problems if it becomes too concentrated. Several commonly used gases are toxic and should be used with caution.

A. BOTTLED GASES

a. Always remember that most bottled gases are under pressure and have all the potential of a bomb.
b. When using or storing a large tank or bottle of compressed gas be sure it is properly secured or anchored, in order to prevent the accidental release of the gas. All precautions must be taken to avoid dropping, knocking over, rolling or dragging or striking cylinders.
c. Transporting cylinders should be done by a cylinder hand truck with a chain to hold the cylinder in place.
d. Cylinders should be chained with a snap fastener and anchored to the wall, or clamped with a belt to a laboratory bench, or supported by a non-tip stand.
e. Check all fittings such as valves and gauges for leaks. Use detergent solutions to determine position of leaks.
f. Indicate the date of acquisition and find out from the supplier or producer if there is a particular life expectancy for that gas.

B. GAS GENERATION EXPERIMENTS

Any experiment involving the generation of a gas has a potential explosion hazard.

a. Toxic gases; should only be generated in a fume hood. A trap should be included at the end of the delivery system which will react with that gas.
b. Combustible gases: a trap should be installed in the line between the gas generator and the delivery to prevent backflow and flashback. After generation the system should be thoroughly flushed in a well ventilated room. No open flames.
c. Oxygen generation: in setting up a generating delivery system for oxygen, do not use any grease or oil lubricants in the system.
d. In all gas generation-delivery systems inspect for leaks and plugs. Be sure the gas can flow freely through the system to prevent pressure build up.

IV. HANDLING GASES

C · TOXIC AND COMBUSTIBLE GASES

a. Several commonly used gases are toxic or flammable and should be used with great caution and only in a hood. The following is a list of hazardous gases with varying degrees of toxicity(1).

acetylene
carbon disulfide
carbon dioxide (in excess quantity)
carbon monoxide
hydrogen cyanide
hydrogen sulfide
mercury vapor
nitrogen dioxide
ozone
phosgene
sulfur dioxide
other combustible gases

---

(1) Laboratory Safety, Vol. 1, No. 7, July, 1965, Department of Environmental Health and Safety, University of Michigan Health Service.

V. WORKING WITH HEAT SOURCES

V. WORKING WITH HEAT SOURCES

Introduction

Sources of heat are essential to laboratory activities. The proper use of such agents will minimize the potential hazard inherent in them. A familiarity with the equipment, a knowledge of the possible dangers, and common sense in dealing with heating agents provide the best insurance for accident-free laboratory activities. This section will attempt to provide some knowledge of the possible dangers and, to some extent, may lead to familiarity with the equipment.

A. OPEN FLAMES

The open flame affords perhaps the most versatile and universally used heat source. However, it also involves several hazards that need to be kept constantly in mind:

1. Volatile or pulverized materials are easily ignited by open flames. (Aerosol bombs are especially dangerous near flames.)
2. Intense heat rising from flames may burn reaching arms or ignite clothing or hair. (Sweaters are particularly hazardous in this regard.)
3. Flames decrease oxygen content and increase carbon dioxide content in the air. (Alcohol lamps.)
4. A metal screen placed over a burner will contain the flame within the area where the heating is desired.
5. When a burner is not being used it should be shut off to avoid inadvertently reaching over or bumping it.
6. Some laboratories are equipped with gas ovens or kilns. These should have pilot lights for lighting the burner. If an oven should have to be lighted by hand, care should be taken to avoid an accumulation of gas prior to introducing the flame. This could easily result in a mild explosion or violent burst of flame. It is good policy always to introduce the flame prior to turning on the gas.

B. ELECTRICAL HEATING

All electric appliances, instruments or tools should be equipped with three-prong, grounding type plugs to minimize the chance of electrical shock.

An electric heating agent may not "look hot" and yet it retains its heat for some time after being disconnected. A hand brought near a suspected object is usually sufficient to determine its relative heat content.

Immersion-type heaters are not recommended for use in science laboratories.

Volatile materials should be heated electrically (or in a water bath) rather than with direct open flames. Even so, volatile materials spilled on an electric hot-plate could burst into flames. This is especially true with the open coil type of hot-plate. The sealed coil design is highly recommended. Another form of sealed coil design is the thermal tape which provides a convenient means of heating volatile substances or irregular containers, and may be used to eliminate undesired condensation in various types of generators.

C. STEAM

Steam under pressure is a potential hazard that should be respected. Gas generating equipment or distilling apparatus must be used with caution to prevent possible pressure build-up. When water is converted to steam, its volume is increased about 1,700 times. By confining this steam, its pressure can be increased, resulting in still higher temperatures. Anyone operating such equipment should be familiar with the unique suggestions or precautions listed by the manufacturer. It is wise to periodically check pressure apparatus for hairline cracks and worn gaskets.

D. HEAT RESISTANT MATERIALS

One of the most common forms of accidents involving heat result from the heating of materials that should not be heated. Most laboratory glassware is designed to be heated and is shock resistant, i.e., it is borosilicate glass (brand names like Pyrex and Kimax). However, some glassware (lime glass or soda glass) does not have this quality and should not be heated except for certain specialized activities. Always make certain that any piece of labware to be heated in routine use is stamped with the brand that indicates its heat resistance. Students should be taught the characteristics of glassware utilized in experiments.

Reference

Curriculum Seminar: Safety in the Science Lab. From Instructors Manual.

Laboratory Waste Disposal Manual, Manufacturing Chemists Association, 1825 Connecticut Avenue, N.W., Washington, D.C. 20009, 1970.

Steere, Norman V., Handbook of Laboratory Safety, Second Edition, Cleveland, Ohio: The Chemical Rubber Co., 1971.

Chemical Safety Slide Rule, National Safety Council, Stock No. 129.91, 425 N. Michigan Avenue, Chicago, Illinois 60611 (approx. $2.00).

Laboratory Safety, Vol. 1, No. 7, July, 1965, Department of Environmental Health and Safety, University of Michigan Health Service.

VI. WORKING WITH GLASS AND GLASS TUBING AND PLASTICS

VI. WORKING WITH GLASS AND GLASS TUBING AND PLASTICS

A. GLASSWARE

1. Where possible it is recommended that plastic equipment be used instead of glass to eliminate the hazard of broken glass.

2. Glassware is intrinsically strong. Failure of glassware is a surface phenomenon. For any glassware that is to be heated, the worker should look for scratches or cracks before using.

B. GLASS TUBING

1. Cutting: After making the initial scratch in the tube with a triangular file, wrap in toweling and break away from you. (Figure a).

2. Fire-polishing: Every piece of glass cut for lab should be fire-polished to eliminate any sharp edges. (Figure b).

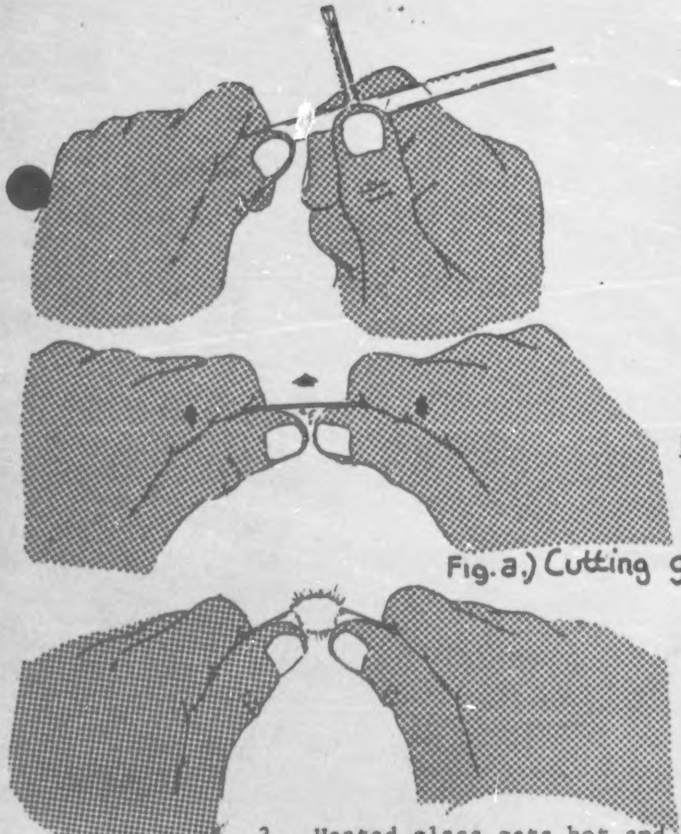


Fig. a.) Cutting glass

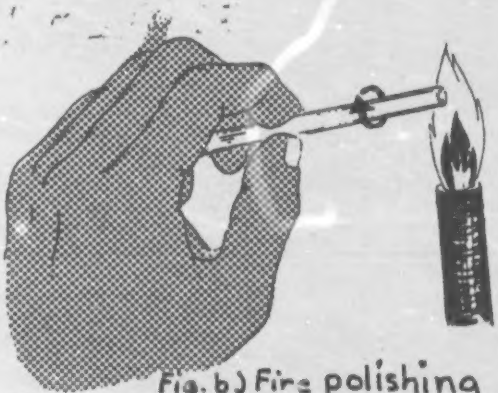


Fig. b.) Fire polishing

HOT GLASS LOOKS LIKE COLD GLASS

3. Heated glass gets hot and stays hot for awhile. This most obvious statement cannot be repeated often enough. Place heated glass on an insulator of some type (i.e., a ceramic triangle or crucible holder) to prevent cracking.

4. Inserting tubing in stoppers (Figure c)

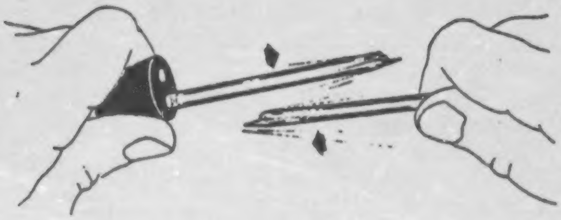
a. The hole in the stopper should be large enough to accept the tubing but small enough to result in a leakproof connection.

b. The tubing should be wrapped in toweling when inserting.

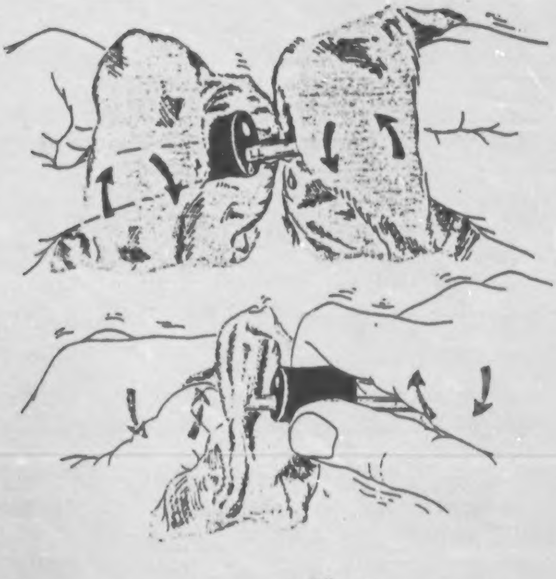
c. The tube or hole should be lubricated before inserting. Check the compatibility of lubricants with reagents being used. (Glycerine with a chlorate could be explosive).

d. After inserting be sure the tube is still open and has not become plugged up accidentally.

Fig.c. DO NOT DO THIS! CAUTION



DO THIS!



C. FROZEN GLASSWARE (2)

If a frozen piece of glassware is encountered, such as a glass stopper frozen in a bottle or a stopcock, extreme care should be used to protect the individual from cuts. A good grade of penetrating grease may free the frozen situation or the use of hot water on the neck of the bottle or pipette or burette may free the part. Mechanical stopper removers are also available that would assist in this operation. Burettes should be stored filled with water, with a small cork inserted in the upper end and the stopcock closed. Pipettes should be stored in a container of water in an up-right position. Students should be permitted to use special cleaning solutions in pipettes only with care and caution.

D. FAILURE OF GLASSWARE

Always check thoroughly all glass materials in advance of experiments. Check for small cracks, weak areas, etc. Be sure all tubing is open and that there is no clogging of the glass passage. Any special generator such as hydrogen generators and special apparatus for the demonstration of the gas laws should be used in accordance with the manufacturer's instructions.

Bell jars and other glass equipment used with an evacuation pump should require care and inspection for cracks and any signs of stress that may develop from age. This would be indicated by discoloration or a cracking appearance in the area so weakened.

E. LABORATORY ACTIVITIES WITH PLASTICS

Due to the wide variety of plastics used in the production of containers, dishes and hardware that might find their way into the classroom or laboratory, it is important that the teacher be aware of the potential dangers that exist if plastic is incorrectly used.

Plasticware comes into the classroom either through specific purchase or in the form of emptied containers. In purchasing plasticware, the specifications should be carefully studied to ensure that the product purchased meets the demands placed upon it. It is when plastic products are used in another manner than the one for which they were intended, that danger sometimes exists.

Plasticware that comes into the classroom as an emptied container holds greater risks, due to the fact that it probably will not be used for the specific purpose for which it was manufactured. It may be thought that an emptied acid bottle would be safe to store other acids, but this might prove false, due either to the kind of acid or the concentration. The risk is multiplied when it is realized that most of the emptied plastic bottles coming into the classroom were designed to hold either bleach, detergent or an insecticide.

A teacher would be wise in running some simple tests to determine the chemical resistance and stress cracking resistance before reusing any plastic container. Certain plastic containers crack very easily, especially at lower temperatures. This factor could be tested first by filling this type of container with water and then determining how much stress it could withstand. The chemical resistance could be determined by placing a piece of this material in a container of the solution to be stored. A plastic's resistance to heat could be tested by applying different degrees of heat to it. These tests should be conducted under a hood or in a well-ventilated area, since many plastics give off poisonous fumes when they melt or burn.

A teacher should keep in mind, when reusing plastic containers, that with age the characteristics of that particular plastic may change. Also, through wear and tear of use, or after being emptied, small holes may have developed. Care should be taken in altering plastic containers that cracks and sharp edges do not develop. (2)

The manufactuer can usually supply more detailed information, if desired.

References:

Chemistry Manual. 2nd Edition. Experimental Foundations Lab. Deitz et al. Prentice Hall. Englewood Cliffs, New Jersey, 1975.

Safety Science Seminar. "Safety in the Science Lab", From Instructors Manual.

Laboratory Waste Disposal Manual, Manufacturing Chemists Association, 1825 Connecticut Avenue, N.W., Washington, D.C. 20009, 1970.

Steere, Norman V., Handbook of Laboratory Safety, Second Edition, Cleveland, Ohio: The Chemical Rubber Co., 1971.

Chemical Safety Slide Rule, National Safety Council, Stock No. 129.91, 425 N. Michigan Avenue, Chicago, Illinois 60611 (approx. $2.00).

Laboratory Safety, Vol. 1, No. 7, July, 1965, Department of Environmental Health and Safety, University of Michigan Health Service.

VII. PROTECTION AND PREVENTION

VII. PROTECTION AND PREVENTION

A. SAFETY EQUIPMENT AND FACILITIES CHECKLIST FOR SCHOOL SCIENCE LABORATORIES

MICHIGAN DEPARTMENT OF PUBLIC HEALTH
OCCUPATIONAL HEALTH

Case histories show that most health and safety problems and accidents are related to a lack of knowledge, an unsafe environment, unattended operations, carelessness or inattention. Seven elements are of special importance in preventing injuries, illnesses or accidents:

1. The development and use of safe methods and procedures.
2. The use of approved, safely designed equipment.
3. The use of adequate and properly designed ventilation systems.
4. Regular inspection.
5. The careful training and indoctrination of new personnel.
6. Continuing health and safety education and supervision.
7. Fire training.

The following check sheet has been prepared for use as a self-evaluation sheet for school laboratory facilities. It is intended to highlight and identify many of the most significant health and safety hazards which may be present in science laboratories.

Laboratory Arrangement	Yes	No
Are exits, aisles and stairways leading to or from laboratories adequate for prompt exit in case of emergency?	___	___
Are exit doors designed to open outward from laboratories?	___	___
Are illumination levels in laboratory work and storage areas sufficient to identify and avoid physical and chemical hazards and to perform assigned tasks in a safe manner?	___	___
Material Storage		
Are laboratory supplies (chemicals, glassware, and equipment) stored in such a manner as to:		
a. Maintain proper identification and labeling?	___	___

Yes No

b. Maintain security? ___ ___
c. Minimize fire hazards? ___ ___
d. Prevent breakage? ___ ___
e. Maintain accessibility without hazard? ___ ___
f. Prevent reactions between chemical compounds? ___ ___
g. Confine contents in case of spill or leak? ___ ___

Chemical Hazards

Are materials such as chlorates, perchlorates, peroxides, nitrates, nitrites and permanganates recognized as strong oxidizing agents capable of causing fires or explosions? ___ ___

Are very flammable materials such as acetone, naphthas, ether, hydrogen, benzene and toluene handled and stored with special care? ___ ___

Are compounds such as arsenic, lead, mercury and cyanides recognized as being highly toxic from the ingestion standpoint? ___ ___

Are compounds such as beryllium, cadmium, lead, hydrogen, sulfide, mercury, fluorine, benzene and carbon tetrachloride recognized as being highly toxic from the inhalation standpoint? ___ ___

Are hydrogen sulfide generators operated within the confines of mechanically ventilated hoods? ___ ___

If perchloric acid is used, is it handled within a special laboratory hood? ___ ___

Is mercury handled and controlled to confine spills? ___ ___

Are any accidental spills of mercury promptly cleaned up by means of a vacuum system with glass separation traps? ___ ___

Safety Equipment

Are safety showers and/or eye wash fountains available and in usable condition in areas where corrosive materials are being handled (areas of potential contact)? ___ ___

Are personal protective devices such as safety glasses, face shields, gloves, aprons and respiratory equipment available and maintained and their use supervised to assure proper protection from laboratory hazards? ___ ___

Are portable and/or fixed safety screens or shields available for use to eliminate hazards caused by splashing, accidental discharge or equipment failure --

a. By students? ___ ___
b. By instructors? ___ ___

Are fire extinguishers readily available for the class of fire likely to be encountered? ___ ___

	Yes	No
Have fire extinguishers been serviced within past year and inspected monthly?	___	___
Are compressed gas cylinders chained or secured against movement?	___	___
Are pressure reducers provided on all compressed gas cylinders in use?	___	___

Ventilation Systems

	Yes	No
Does storage area have a general ventilation system that operates continuously or can be turned on in case of leakage or spill?	___	___
Is the light and ventilation system switch explosion proof or located outside zone of likely contamination?	___	___
Are laboratory hoods provided and used where hazardous exposures to toxic substances may occur or develop?	___	___
Is the mechanical ventilation in laboratory hoods adequate to control contaminants generated therein?	___	___
Is hood performance periodically checked with smoke, boiling water or airflow meter?	___	___
Have exhaust system discharge points been checked to assure minimum likelihood of contaminant re-entry into building or adjacent occupancies via air intakes, window, doors, etc.?	___	___

Medical Services and First Aid (Not Emergency Facilities)

	Yes	No
Have arrangements been made for first aid and medical advice in the event of accident or medical problems?	___	___
Are first aid and accident procedures posted?	___	___
Are phone numbers of fire department, ambulance and physician posted?	___	___
If first aid is to be provided on site:		
a. Has the first aid supply list been approved by physician?	___	___
b. Are regular checks of first aid supplies made?	___	___
c. Is a person trained in first aid available?	___	___

B. SAFETY EQUIPMENT AND FACILITIES CHECKLIST

Introduction

The following is a summary of "Emergency Equipment and Clothing" from Safety in Academic Chemistry Laboratories, American Chemical Society.

Facilities and Safety Equipment - General Checklist

All chemistry labs should have:

____ 1. Safety showers.
____ 2. Dry chemical powder or carbon dioxide-type fire extinguishers. See page 34.
____ 3. Fume hoods.
____ 4. Eye protection devices for students and staff. (Appendix E).
____ 5. Eye wash facilities.
____ 6. An alarm for evacuation laboratory. (Readily accessible to instructors). It should sound only for lab concerned.
____ 7. Well marked, unimpeded exits.
____ 8. A general alarm system for the entire building.
____ 9. Provisions for safe storage and transportation of chemicals. (Incompatible chemicals should never be stored in close proximity).
____10. A carefully planned chemical disposal procedure. (Must follow EPA rules or other local, state, and federal regulations). The following company will dispose of chemicals for schools: Nelson Chemicals, 12345 Shaefer, Detroit, MI, 933-1500.
____11. Protective clothing-lab aprons, coats, gloves made of a chemically inert material.
____12. First aid equipment with sufficient personnel trained in its use.
____13. A file of current safety publications. The file should be accessible to students and visitors. The instructor should encourage its use.

Emergency Equipment and Clothing

1. Eye Protection

   a. Students must be provided with proper eye protection or required to provide their own. (glasses, goggles, face shields). Act No. 54 of the Public Acts of 1972. Enrolled Senate Bill No. 553.
   b. Eye protective devices should be provided for visitors and personnel.
   c. Contact lenses should be prohibited in the lab. If a chemical is splashed into the eye, it will become trapped under the lens and irrigation will be ineffective.
   d. Devices should be sanitized after each use.

2. Eye Washes

   a. Eye wash fountains should deliver a gentle flow of clean, aerated water.

b. A hand held eye wash spray with a 5-foot hose is more adaptable. Rubber tubing can be attached to a faucet for ready use. It may be used as an eye wash and as a head and body wash.
c. Eye wash devices should be flushed weekly.
d. Eye wash devices should not be located where they can be contaminated by wastes.
e. A 15 minute wash is recommended.

3. Fire Extinguishers

a. Extinguishers should be appropriate to the specific need. (An ABC type extinguisher is recommended for general use).
b. There should be at least one extinguisher for each work bench.
c. Extinguishers should be charged promptly after each use. (At least a 10-lb. charge).
d. At least one dry chemical poster-type extinguisher should be provided for back-up use.
e. Carbon tetrachloride and most other halohydrocarbons should not be used because of their hazards: toxicity of vapors, the decomposition products, and their chemical reactivity under fire conditions.
f. At least one fire blanket should be provided for ready use.

4. Refrigerators

a. Domestic refrigerators should not be used for chemical storage unless modified by removing sources of open electrical contacts (i.e., bulbs) and replacing the door closure with easily opened magnets.
b. In frost free refrigerators, bottom drain should be plugged to prevent spillage and vapors from coming in contact with the motor.
c. Food and chemicals should never be stored in the same refrigerator.
d. Stored chemicals must be securely closed and properly labeled.
e. A regular defrosting schedule should be maintained.
f. Old chemicals should be discarded.

5. Sinks

a. Lab sinks should have rubber or plastic mats in the sink and on the drain.
b. Each sink should have ample hot water and soap.
c. Drainage from lab sinks should be kept separate from sanitary drainage.

6. Safety Showers

a. The valve handle should be rigidly fixed and plainly labeled.
b. The valve should readily open in either direction and remain open until intentionally closed.
c. Water flow must be sufficient to drench the subject rapidly.
d. Shower area must be free from obstructions.
e. Pure, tempered water should be used.
f. Showers should be tested on a regular basis. A record should be kept of such tests.

7. Aspirators

   a. Aspirators or aspirator bulbs should be used for drawing liquids into pipettes; never use the mouth.

Reference:

Safety in Academic Chemistry Laboratories, American Chemical Society, Committee on Chemical Safety, March, 1974, Revised January, 1976.

80

C. INSPECTION: LABORATORY CHECKLIST

SCIENCE TEACHER ______________________________ ROOM ________________

DATE ______________________________

Items	Remarks	yes/no	Beginning of school year	Daily	Weekly	Monthly	End of school year
Fire Drill Regulations	Properly posted	______	x		x	x	x
Fire Extinguisher	Charged	______	x			x	x
Fire Blanket	Serviceable	______	x			x	x
Sand Buckets	Full, dry, and clean	______	x		x	x	x
Safety Shower	Serviceable	______	x			x	x
Eye Fountain	Serviceable	______	x			x	x
First Aid Cabinet	Properly stocked	______	x		x	x	x
Water Faucets	Closed	______	x	x			x
Drains	Open	______	x	x			x
Exits	Clear and in working order	______	x	x			x
Electrical Outlets	Serviceable	______	x			x	x
Counters	Clean and orderly	______	x	x			x
Gas Valves	Closed	______	x	x			x
Master Utilities Switches	Serviceable	______	x			x	x
Exhaust Systems	Operable	______	x		x		x
*Fumehood	Operable	______	x			x	x
Chemical Storage Room Ventilation	Operable	______	x		x		x
*Storage of Chemicals and Equipment	Orderly and safe	______	x		x		x
Lab Reagents	In designated location and stoppered	______	x	x			x
*Flammable Materials	Securely stored	______	x		x		x
*Explosive Materials	Securely stored	______	x		x		x
*Student Storage Space and Equipment	Clean and safe	______	x			x	x
Waste Containers	Emptied and clean	______	x		x		x
*Machinery Safety Features	Operable	______	x			x	x
*Pressure Equipment Safety Features	Operable	______	x			x	x

Items	Remarks	yes/no	Beginning of school year	Daily	Weekly	Monthly	End of school year
*Vacuum Equipment Safety Features	Operable	______	x			x	x
*Eye Protective Devices	Sanitized and usable	______	x	x			x

Comments: ____

*NOTE: When specific chemicals, materials and apparatus indicated are in daily use, more frequent inspections should be made than indicated above.

Science Advisory Committee
Curriculum Division
Michigan Department of Education
Lansing, Michigan 48902

Communication
the key to safety

Safety Education and Training Division
Bureau of Safety and Regulation
Michigan Department of Labor
300 East Michigan Avenue
Lansing, Michigan 48926

D. STUDENT AND TEACHER PROTECTION

1. The School Science Accident Problem

Accidents occur wherever there is human involvement. They are as old as mankind.

Accidents, the primary cause of death and disability of school age youth, are a major concern of the people involved in elementary and secondary science instruction. According to the National Safety Council, accidents claim more lives of children 1-14 years of age than the six leading diseases combined. Children in the elementary school are involved in numerous accidents in classrooms. Accidents involving junior and senior high students occur not only in physical education and industrial arts classes, but also in science classes.

2. Behavior

Human behavior is considered by many safety educators to be the primary cause of accidents. Car, home, industrial and school accidents are many times the results of an individual's unsafe behavior patterns. These behavior patterns that lead to accident producing events can be observed in elementary, middle-junior high and senior high school students as well as adults. Unsafe behavior may be the result of a single factor or may result from a combination of factors. Fundamental accident causes can be defined in two categories:

1. Unsafe behavior or human factor.
2. Unsafe environment.

As to human failure, it is considered by many to be the primary case of accidents. Horseplay, cartoon-type humor, running, chasing or throwing things, acting silly all contribute to an atmosphere that increases accidents in the laboratory.

3. Attitudes

The attitude of a person is usually thought of as being the most important cause of accidents which occur in the home, school, or elsewhere. A positive attitude, the wanting to do something. correctly, is considered a sound approach for a person to use for self preservation. Improper attitudes that may be considered unsafe are:

- Violent temper
- Absentmindedness
- Willful intent to injure
- Nervous, excitable, etc.
- Willful disregard of instructions, regulations and rules.
- Failure to report accident in accordance with regulations.

4. Skills

The performance of a task without the required skills may result in an accident in the science classroom/laboratory. Skill and task requirements should be compatible for safe performance. Lack of awareness of hazardous materials and operational hazards, as well as lack of experience and training can result in all types of predictable accidents.

5. Knowledge

To avoid accidents, an understanding and knowledge of a particular task are necessary as well as recognizing the hazards involved in a particular task. A basic knowledge of science safety procedures and standards is essential for the educator and particularly the teacher involved in science instruction.

6. Physical Impairments of persons in the lab may also contribute to increasing the accident risk, due to:

- Defective eyesight
- Defective hearing
- Muscular weakness
- Fatigue
- Crippled
- Existing heart or other organic weakness
- Intoxicated
- Existing injury (cut, laceration, bruise, cast)

E. SCIENCE FAIR ACTIVITIES

1. Rules and regulations

Science fair rules often ban the use of strong reagents, open flames, explosives and materials liable to spontaneous combustion, dangerous gases, poisons, pathogenic organisms and other troublesome materials or activities. Teachers should be familiar with and acquaint students with the rules governing any science fair, exhibit or contest for which projects may be developed. To illustrate this, portions of a selected set of materials relating to science fairs are presented at this point.

2. Science Fairs

The following rules were taken from the Tenth Annual Florida State Science Fair Bulletin:

a. The Fair Committee will make every effort to safeguard all projects and equipment, but the responsibility for the security of entries rests with the individual contestant.

b. Every effort should be made to provide proper tools to maintain the exhibit and to safeguard these tools and spare parts with tool boxes with locks.

c. The exhibitor is required to remain with his exhibit, as indicated in the program, while the fair is in progress. Each contestant should have someone observe his exhibit repeatedly to keep it in perfect order.

d. All wiring, switches, and metal parts that carry at least 110-volt currents (radio and electronic apparatus) must be located out of reach of observers. Open knife switches or doorbell push buttons may not be used on 110-volt circuits. All electrical apparatus must be provided with a suitable cord, switch and durable attachment plug with parallel pins. All electrical apparatus must be constructed according to standard electrical safety laws. If in doubt, consult a competent electrician.

e. No dangerous or flammable chemicals may be used in an exhibit.

f. No live poisonous animals will be permitted in exhibits under any circumstances.

g. The use of radioactive materials and other sources of ionizing radiation will be in compliance with the Federal Register, Title 10, Chapter 1, Paragraph 20.104, "Exposure of Minors."

h. The Fair Director reserves the right to refuse an exhibit considered by him to be unsafe.

3. Selection of project

Projects prepared by students should definitely be given a thorough safety check.

Teachers should not only question students concerning the safety precautions taken in a project, and their understandings relative to the specific hazards and precautions necessary for them, but should also personally check the projects or request some other knowledgeable person to do so. Any project which will be viewed by the public should be constructed so that "inquisitive observers" are protected from possible accidents as well as those who merely look. Provisions such as these will also help to cut down or eliminate careless handling by the occasional souvenir hunter.

VIII. FIRST AID

REFERENCE PAGE FOR FIRST AID

For a list of the objectives and proper behavior of the person giving the first aid, see page 70.

This section contains a first aid procedure checklist for:

Breathing failure . . . . page 71
Shock . . . . page 71
Burns . . . . page 71
Cuts and Punctures . . . . page 71
Fainting . . . . page 71
Substance in the Eye . . . . page 71
Substance in the Mouth . . . . page 72
Electric Shock . . . . page 72
Allergies . . . . page 72

A complete first aid cabinet should contain a specific number of items. For a complete list see page 73.

A record of the accident should be completed whenever an injury occurs in a chemistry lab. For sample report forms, see pages 75, 76, and 77.

VIII. FIRST AID

Introduction

First aid is the "immediate and temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained." (1,2,3). The first objective is to save life:

- Prevent heavy loss of blood
- Maintain breathing
- Prevent further injury
- Prevent shock
- Send for a physician

The first aider must also:

- Avoid panic
- Inspire confidence
- Do no more than necessary until professional help arrives

Common sense and a few simple rules are the keys to effective first aid.

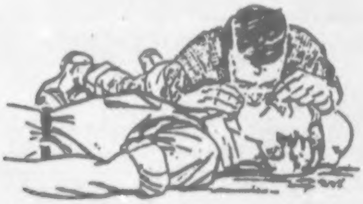
Following all required First Aid procedures, either send student to health clinic or follow procedures determined by school policy. Maintain an accident record for your own protection. (The checklist shown here may be duplicated only for your personal use.)

A. EMERGENCY FIRST AID PROCEDURES CHECKLIST

The following is a checklist that may be used as a quick report form for reporting accidents and keep a record of action taken.

1. Breathing Failure (Artificial Respiration)

   - Clean mouth of foreign matter.
   - Tilt victim's head back so chin is pointing up.
   - Place your mouth over victim's mouth and pinch victim's nostrils.
   - Blow vigorously (12 times per minute for adult and 20 times per minute for child.)
   - Continue until breathing resumes and victim becomes conscious.
   - Treat for shock.



2. Shock

   - Cover victim with a blanket to prevent loss of body heat.
   - Keep away from excessive heat.
   - If victim is conscious, give plain water, neither hot nor cold.

3. Burns (heat or chemical)

   - Immediate and continuous irrigation with cold water is essential (showers, tap, jugs).
   - If skin is not broken, ice may be used to relieve pain.
   - Send or take student to health clinic.
   - In case of severe burns, use cold water and get medical help immediately.

4. Cuts and Punctures

   - Cleanse wound with cool water (tap) and allow wound to bleed to cleanse itself.
   - Place sterile gauze on wound and exert pressure on wound (if no foreign body in it).
   - Elevate the part that is bleeding.
   - In case of dismemberment, keep part clean and cool, get medical help immediately.

5. Fainting

   - Have student sit down with head between the knees or lie down with feet elevated.
   - Loosen all tight clothing about neck, chest and waist.
   - Break an ammonia vial, and wave it under the nose.
   - Offer coffee or tea when fully conscious.

6. Substance in the Eye

   - Wash (by splashing) with clear water for 15 minutes or open eyes under water. (Use eye fountain if available).

KEEP CALM

7. Substance in the Mouth

- Do not swallow.
- Wash out with water.
- Identify substance:____________________.
- If substance is swallowed, get immediate medical assistance.

8. Electrical Shock

- Turn off power.
- Quickly release victim if current cannot be shut off. (Breaker inoperative or location unknown).
- Use any dry non-conductor (rubber gloves, clothing, wood, rope) to remove either victim or conductor.
- Apply artificial respiration at once, seconds count.
- Obtain assistance but do not stop artificial respiration for any reason until arrival of medical assistance or until normal breathing resumes.

9. Allergies

- Determine, in advance, if students have any allergies.
- Treat for shock, if necessary, and get immediate medical assistance.

10. Other

____

____

Student Name ________________________________

Class ___________

Time ___________

Person(s) notified or needed:

____

____

Date ___________________

Teacher Signature ____

References:

1. First Aid Procedures, University of Waterloo, Ontario, Canada, 1975.
2. First Aid and Emergency Procedures in Schools, Michigan Department of Health, Michigan Department of Education, 1966.
3. Science Safety, Department of Education, Virginia, Richmond, Virginia, 1976.

B. FIRST AID FACILITIES AND SUPPLIES

The Michigan Department of Occupational Health suggests that a SPECIFIC FIRST AID CABINET be maintained in a well-lighted, clean area that has a table, running hot and cold water, soap, and chairs. As a minimum, the first aid cabinet should contain the following SUPPLIES or their equivalent as specified by the employer's medical advisor.

MINIMUM REQUIREMENTS	NUMBER OF PERSONS
Adhesive bandages, individually packaged	16
Ammonia inhalant	1
Antiseptic swabs, individually packaged	10
3" x 3" gauze pads, individually packaged	10
2" x 10 yd. gauze bandage	2
Triangular bandage	1
Adhesive tape, rolls	2
Scissors	1
Tweezers	1
Cleansing tissue, package	1
Antiseptic solution, aqueous mercury preferred	1
Mild soap, capped squeeze bottle	1
Elastic bandage	1

* Simple splints should be added to the above list where fractures are not unlikely.

* Burn preparations have been omitted from the above list. This subject should be discussed with the medical advisor.

* Reserve supplies should be available to replenish the minimum specified supplies at least weekly.

AUXILLARY FIRST AID KITS at one or more locations should be monitored frequently for upkeep and maintenance of supplies.

EMERGENCY NUMBERS such as Ambulance, Hospital, Physician and Poison Control Centers should be posted in both central and auxillary first aid areas.

C. SAMPLE ACCIDENT REPORT FORMS (1, 2, 3) that follow are included here as examples for either the teacher's personal file, a departmental file or a building file.

The Emergency First Aid Procedures Checklist shown on page 71 can also be used as a report form by checking treatment and recording pertinent data.

Accident Report For Teacher SAMPLE 1

1. Name (Print) ______________________________
(Last) (First)

Age ________ Sex ________ Grade ________

2. Parent/Guardian Name ______________________________

Home Phone ________________ Business Phone ________________

3. Injury Date ________________ Time ________________

Location (Room) ________________

Nature ________________

4. Treatment First Aid Information

Sent to Office/Nurse ________________

Hospital ________________

Doctor ________________

5. Description of Accident

Complete description ________________

____

____

Equipment involved ________________

____

Witnesses ________________

6. What steps should be taken to prevent similar accidents in the future? ________

____

7. Teacher ________________

Accident Report For Teachers

SAMPLE 2

Age ____ Sex ____ Grade ______

Name (Print) ____
(Last) (First)

Address ____________________ City ______________ Phone ______________

Parent/Guardian __________________________ Business Phone ______________

Teacher ____________________ Room ______________ Class ______________

Date & Time of Accident ____

Location of Accident ____

Nature of Injury ____

Treatment of Injury ____

Description of Accident: Give a complete description of what was taking place when the accident happened, location, equipment involved, witnesses, etc.

____

____

____

Check Cause:

____ 1. Experimenting or working without authority.
____ 2. Making safety devices inoperative.
____ 3. Failure to use personal protective devices.
____ 4. Distraction, teasing, horse play.
____ 5. Unsafe clothing or hair.
____ 6. Hazardous arrangement or experimenting.
____ 7. Ignored instructions.

What safeguards or protective equipment were being used at time of accident?

____

What safeguards should be used? ______________________________

____

What steps were taken to prevent similar injuries? ______________________

____

General Comments: ______________________________________

____

SAMPLE 3

TO: The Principal or Other Designated Person(s)

DATE________________

SCHOOL________________

FROM: Science Teacher

Employee Identification Number

______________________________ ______________________________

(Signature)

1. Incident Occurence:

Date:____________________ Time:____________________ AM/PM

Exact Location:____

2. Personal Injury Property Damage

3. Description of Incident

____

____

4. Personal Injuries:

Name:	Address:	Age	Occupation

5. Was first aid administered? ☐ Yes ☐ No By whom? ____________________
6. Were Parents or Guardian notified? ☐ Yes ☐ No
7. Was injured person attended by a physician? ☐ Yes ☐ No
8. Name of attending physician? __________________________________
9. Was injured person admitted to a hospital? ☐ Yes ☐ No
10. Description of property damage:

____

____

11. Witnesses:

Name	Address	Age	Occupation

12. Safety equipment used:

☐ Fire Extinguisher ☐ Safety Glasses ☐ Shower ☐ Fire Blanket ☐ Other________

APPENDICES

Appendix A:

LIABILITY AND TEACHERS

In order for you to be aware of the legal implications that are associated with teaching you should be familiar with the following:

a. Sovereign immunity
b. Criminal negligence
c. Tort laws

In the past in many states the schools were considered to be a subordinate unit of the state government and as such were protected from suits in cases of bodily injury which resulted from the negligence of an employee under what was known as Sovereign Immunity. Simply stated it meant that you couldn't sue the King or the state. Some teachers who have heard of sovereign immunity have had the mistaken idea that they were also protected from suit, this is not the case. In fact in recent years in Michigan school boards and board members have found that the idea of sovereign immunity is no longer accepted by the courts. School boards and teacher associations now carry insurance to provide some protection for their employees.

Criminal negligence involves committing a crime against society which may involve injury or death to another individual. In a case of criminal negligence the individual is already committing a crime when the injury or death occurs which in itself would subject him to arrest, trial, and imprisonment. An example might be a teacher driving a school bus full of students on a field trip while under the influence of alcohol or drugs.

In a school accident a teacher may not be charged under criminal negligence and yet be taken to court in a tort lawsuit. Whereas in criminal negligence a crime is committed against society; in committing a tort one may break the law against an individual. A tort is defined as a civil wrong committed against another person. There are four elements which must be shown if a person is to be held liable in a tort lawsuit. They are:

1. "Duty" All people owe all other people the duty of not infringing their right to be free from physical and mental injury. As a teacher you then should know what your duty is in relation to your students.

2. "Violation or Breach of Duty" When an individual has infringed another's rights he has violated or committed a breach of duty.

3. "Cause or Proximate Cause" If a student is injured and the injury might have been prevented by you the teacher performing your job in a reasonable manner, then you could be the "proximate cause" for that injury.

4. "Injury" In the case of a student, the infringement of the individual's rights by you as the teacher results in the student being injured either physically or mentally.

One key factor in such suits is the idea of reasonableness. If the teacher acts in a manner that could be expected by any other teacher in a similar situation then he is not guilty of a tort violation.

Gatti offers these guide rules for teachers in considering liability and teacher responsibilities under the law:

GUIDE RULE	BEING A TEACHER MAKES YOU RESPONSIBLE FOR YOUR STUDENTS' INSTRUCTION, SUPERVISION AND SAFETY. IF YOU DO NOT FULFILL THIS RESPONSIBILITY, YOU MAY BE HELD LIABLE.[1]

You can be held liable for anything that you have done which is improper or wrong. The key to your actions is "reasonableness". Gatti in describing negligence explains it in terms of reasonableness as follows:

> Negligence is: not doing something which the reasonable teacher, considering the circumstances, would ordinarily do; or doing something which the ordinary teacher of reason and prudence would not do.[2]

He further offers these rules concerning negligence and reasonableness:

GUIDE RULE	NEGLIGENCE EXISTS WHERE THE ACTIVITY OR CONDUCT ON THE PART OF THE TEACHER CREATES AN UNREASONABLE CHANCE OF DANGER. WHEN THE TEACHER IGNORES THE DANGER, OR DOES NOT SEE THE DANGER WHEN HE SHOULD, HE MAY BE HELD NEGLIGENT IF SOMEONE IS INJURED AS A RESULT.[3]
GUIDE RULE	DID THE ACT WHICH CAUSED THE INJURY EXCEED REASONABLE LIMITS, TO THE POINT WHERE THE TEACHER WAS NOT ACTING WITHIN THE RIGHTS OF HIS EMPLOYMENT? IF SO, HE IS RESPONSIBLE.[4]

Gatti also states that a teacher should not only have safety rules for the students to follow in the class but the teacher should also see that the rules are enforced.

GUIDE RULE	IF A RULE IS BROKEN, STEPS MUST BE TAKEN TO ASSURE THAT THE INFRACTION WILL NOT OCCUR A SECOND TIME. IF A TEACHER DOES NOT TAKE FURTHER STEPS, HE MIGHT BE FOUND LIABLE ON THE GROUNDS THAT THE RULE DID NOT REALLY EXIST, EXCEPT ON PAPER.[5]

Along with reasonableness the idea of forseeability is important in determining if a teacher has acted in a responsible manner. Gatti offers the following rule on forseeability:

GUIDE RULE	INJURY IS GENERALLY FORESEEABLE IN SITUATIONS (1) WHERE LARGE CROWDS OF STUDENTS ARE GATHERED WITHOUT SUPERVISION; (2) IN SPECIALIZED ACTIVITIES IN VOCATIONAL EDUCATION, PHYSICAL EDUCATION AND SCIENCE CLASSES; OR (3) IN CASES WHERE YOU ARE ABSENT FROM THE ROOM FOR AN UNREASONABLE AMOUNT OF TIME.[6]

---

[1] Gatti, Daniel Jon. The Teacher and the Law. West Nyack, New York. Parker Publishing Co. Inc. 1972. Page 19.

[2] Ibid. Page 52.

[3] Ibid. Page 32.

[4] Ibid. Page 22.

[5] Ibid. Page 57.

[6] Ibid. Page 62.

Appendix B:

MICHIGAN OCCUPATIONAL SAFETY & HEALTH

Act 154 of P.A. 1974

Department's Authority

Make inspections of work places based upon employee complaints concerning alleged hazardous working conditions.

Conduct unscheduled inspections at reasonable times and in a reasonable manner of all places of employment in order to physically inspect work areas for compliance with safety standards.

Advise an employer that an imminent danger exists and issue administrative orders requiring that steps be taken which are necessary to avoid, correct, or remove the imminent danger.

Issue citations and proposed penalties to any employer for failure to comply with standards, rules, order or provisions of this Act.

Issue cease operations orders when an employer fails to comply with a final order of the Board.

Employer's Responsibilities

Furnish and maintain a work environment which is free from recognized hazards that are causing or likely to cause death or serious physical harm.

Comply with specific Occupational Safety and Health Standards that apply to working conditions in their establishments.

Post notices and use other required or appropriate means of informing employees of their protections and obligations under the Act.

Post all citation appeal decisions in the same manner as citations so as to inform employees.

Employee's Responsibilities

Comply with all applicable Occupational Safety and Health Standards established under the Act.

Refrain from removing, displacing, damaging, destroying, or carrying off a safeguard furnished or provided for use in a place of employment or interfering in any way with the use thereof by any other person.

Employee's Rights

Entitled to work in a place of employment free from recognized hazards that are causing or are likely to cause death or serious physical harm.

May file a written request with the Department for an inspection where it is believed that a violation of a standard exists. Entitled to have identity withheld and to receive a written reply of Department findings.

May request an immediate inspection when an alleged imminent danger exists.

Authorized employee representative is entitled to accompany the Department representative during an inspection or investigation.

Authorized employee representative is entitled to a conference with the departmental representative to review findings upon completion of an inspection or investigation.

Entitled to know that a citation was issued by the Department through the posting of such citation near the place of violation.

Entitled to receive medical tests or examinations when required by a standard.

Entitled to be apprised by employer of a health hazard to which he or she is exposed when the hazard is covered by a standard.

Entitled to protection against being discharged or otherwise discriminated against for filing a complaint or instituting a proceeding under this Act.

NOTE: Where employees select a person to represent them, employee rights may be exercised by the "authorized employee representative" as provided in the Act.

For further information contact:

Michigan Department of Labor
Bureau of Safety & Regulation
7150 Harris Drive
Lansing, Michigan 48926
General Industry Division (517) 37-39620
Construction Safety Division (517) 37-39634
Safety Education & Training (517) 37-39160

ITS 1749 - 10/75

Appendix C:

HANDICAPPED STUDENTS

Some special precautions should be taken for the safety of handicapped students. The following are some guidelines.

1. The work area should be low enough to allow a student in a wheelchair to work safely. It should be constructed so that spills onto the student is prevented.
2. Whenever possible, ramps, as well as stairways, should be provided for students in wheelchairs.
3. Students in wheelchairs should be assigned work areas near exits and non-handicapped laboratory partners.
4. Students who have hearing or vision handicaps should be assigned responsible laboratory partners who are without handicaps.
5. Students who have unusual emotional, or behavioral problems should be identified at the start of the semester and be carefully monitored when using dangerous, or expensive equipment. They should be removed from the classroom when their behavior could cause a hazard to themselves or other students.

Appendix D:

FEDERAL AND STATE LAWS

1. Rocket and Missile Launching, Federal Aviation Regulation Part 101. Governs the size, type, construction, and launching considerations of model rockets. Minimum size rockets that would fall under control of this regulation would be illegal in Michigan, as they would exceed maximum allowable specification under Michigan's Model Rocket Law.

2. Michigan Model Rocket Law, Act. 333, P.A. 1965, Michigan Statutes Annotated of 1965 (18,1236)
   Specifies the size, type, construction, testing, and launching requirements for model rockets.

3. Registration of labs Handling Pathogenic Micro Organisms, Act. 308, P.A. 1927, Michigan Department of Public Health, 3500 N. Logan Street, Lansing, Michigan. Requires the registration of all laboratory facilities utilizing pathogenic micro organisms.

4. Registration of Labs for the Human use of Animals, Act. 241, P.A. 1947, Michigan Department of Public Health, 3500 N. Logan Street, Lansing, Michigan. Requires the registration of each individual laboratory facility utilizing animals for experimental purposes. It should be noted that keeping animals for the purpose of observing their natural growth and development would not require registration.

   340.365-As part of the curriculum, every public school teacher in Michigan shall teach kindness and justice to, and humane treatment and protection of animals and birds.

5. Registration for all sources of Ionizing Radiation, Act. 88, P.A. 1943, Michigan Department of Public Health, 3500 N. Logan Street, Lansing, Michigan. Requires the registration of all sources of ionizing radiation, regardless of level. This would include radioactive isotopes and materials, X-ray machines, and cathode ray tubes (i.e. black lights, shadow tubes, etc.) Anytime high voltages lead to high speed particles being produced, registration may be necessary.

6. School Fire Safety Regulations, Act. 207, P.A. 1941, Fire Marshal Division, Michigan State Police, 416 Frandor Avenue, Lansing, Michigan.
   Governs the design, construction, and operation of school facilities with respect to fire safety. Chemical storage requirements are a part of this act.

7. Occupational Safety, Act. 282, P.A. 1967, Michigan Department of Labor, 300 E. Michigan Avenue, Lansing, Michigan.
   Mandatory safety standards are promilgated under this act that effect all areas of the school facility. Standards requiring the guarding of power transmission equipment, floor and wall openings and stairways, and eye and face protection are but a few. Complete sets of current standards may be obtained from the Occupational Safety Standards Commission, Michigan Department of Labor.

8. Act No. 54 of the Public Acts of 1972- Requires students, teachers and visitors to wear industrial quality eye protective devices when exposure to danger exists. Eye protective devices must be sanitized prior to use. The law lists a wide variety of potentially dangerous situations in which glasses should be worn.

Appendix E: COMPARISON CHART

EYE PROTECTIVE DEVICES

Type	Splash Protection Front	Splash Protection Side	Impact Protection Flying Object Front	Impact Protection Side	Protection Neck and Face	Comfort to Wearer	Est. Acceptability to Student	Use Life Time	Cost
Goggles	Excellent	Excellent	Excellent	Excellent	Poor	Fair	Poor	Fair	Moderate to inexpensive
Glasses (no shields)	Good	Poor	Excellent	Poor	Poor	Good to Very Good	Very Good	Very Good	Moderate
Glasses (shields)	Good	Good	Good	Fair	Poor	Good	Good	Very Good	Moderate
Face-Shields (various sizes)	Excellent	Good to Excellent	Excellent (if adequate thickness)	Good to Excellent	Depends on type and length	Fair	Good for Short Periods	Fair	Moderate (depending on type)
Filter Lenses*									

*Examples: welding, glass-blowing, high intensity light sources, lasers

Reference: ANSI Z87.1 (1968) Occupational and Educational Eye and Face Protection available from American National Standards Institute, Inc., 1430 Broadway, New York, N.Y. 10018

Chart prepared by A.H. Christian

Source: Safety In Academic Chemistry Laboratories, American Chemical Society.

Appendix F:

The following list of specific chemicals is modified from the Explosives Research Section Safety Handbook of Picatinny Arsenal, Dover, New Jersey, dated December, 1959. It is not complete, and is intended as a rough guide only. A thorough literature search should be made on new compounds.

Acetic acid (glacial) will ignite at elevated temperatures (flash point, 140°C). It will also irritate the skin and the mucous membranes of the mouth and throat. MAC, 10 ppm in air. Incompatibles: chromic acid, nitric acid, hydroxyl containing compounds, ethylene glycol, perchloric acid, peroxides, and permanganates.

Acetic anhydride, same as above. Reacts violently with some hydroxyl compounds; it is known to explode with ethylene glycol and $HClO_4$.

Acetone decomposes violently when brought into contact with H_2SO_4/HNO_3 mixtures such as are used in nitration reactions. This is especially true when the reaction is partially confined by dropping the acetone into a narrow-mouthed bottle containing the mixed acids.

Acetone water solutions are flammable over a very wide range. A 5% solution will flash at 60°C if an ignition source is present. The higher the percentage, the lower the flash point, until pure acetone is reached, with its flash point of -14.8°C. MAC, 1000 ppm in air. Narcotic. Explosive range, 2.55-12.8%.

Acetylene, under certain conditions, forms highly explosive compounds with cuprous iron, silver, and mercury. These compounds are easily detonated by heat or shock. Flash point, 0°F (C.C.). Explosive range, 2.5-80%. Usually acts as a simple asphyxiant. Incompatibles: chlorine, bromine, copper, silver, mercury, and fluorine.

Alkali and alkaline earth metals such as sodium, potassium, cesium, lithium, magnesium, calcium, and aluminum are hazardous in these ways: (1) Explosions or fire resulting from contact with water, chlorinated hydrocarbons, or other reactive agents; (2) fires resulting from exposure to air; (3) personnel injury from direct contact with hot metals; and (4) caustic burns from the residue of reaction with water. Storage areas must be dry. Prometallic hydrides produce hydrogen on contact with water and sufficient heat to ignite the gas with explosive rapidity. Waste scraps of these materials should be added in small portions to a high-boiling alcohol such as propanol or butanol and disposed of after all reaction ceases. Do not use CO_2 or sodium bicarbonate dry-chemical extinguishers.

Aluminum chloride added to nitrobenzene containing 5% phenol rises in temperature and explodes violently. Heating nitrobenzene with either $AlCl_3$ or phenol causes no explosion, but at 120°C the three together react violently and form a tar. This shows the danger of working with $AlCl_3$, nitrobenzene, and an oxidizable material. $AlCl_3$ will react with water or steam to form heat and fumes of HCl.

Ammonia (anhydrous) - MAC, 100 ppm in air. Irritating to eyes and mucous membranes. Incompatibles: mercury, chlorine, clacium, hypochlorite, iodine, bromine, and hydrogen fluoride.

Ammonium nitrate decomposes exothermally above 160°C, producing gaseous decomposition products. With large quantities or in a confined space, this reaction develops into a violent explosion. Mixtures with oxidizable substances, such as metal powders and organic materials, are liable to a spontaneous exothermic reaction and can explode.

Aniline is a blood poison and can enter the body through the skin, the lungs, and the digestive tract. It has little appreciable local irritating action, but illness can result from inhalation of vapors or from absorption through the skin. As a result, aniline should only be used in a hood. Many derivatives of aniline (such as methyl violet, nitraniline, dimethylaniline and diaminobenzene) have similar poisonous properties. MAC, 5 ppm in air. Incompatibles: nitric acid and hydrogen peroxide.

Benzene is both flammable and highly toxic, and it should never be used where another solvent can be substituted. Its vapor is considerably heavier than air, so it can travel along floors and benches. Benzene and its homologs should never be poured down a sink. Flash point, 12°F (C.C.); MAC 35 ppm in air. Incompatibles: nitric acid and other oxidizing agents.

Bromine (liquid) causes immediate burns on the skin and mucous membrane. Bromine should be handled only in a hood, using goggles and rubber gloves. MAC, 1 ppm in air. Incompatibles: ammonia, acetylene, butadiene, butane and other petroleum gases, hydrogen, sodium carbide, turpentine, benzene, and finely divided metals.

Carbon disulfide is poisonous, endothermic, and can be detonated by shock. Flash point, 22°F (C.C.); autoignition temperature, 257°F; MAC, 20 ppm. Mixed with air or oxygen, it forms a violently explosive mixture which can be fired by flame or shock, or be catalytic agents such as rust.

Carbon monoxide is highly toxic and especially treacherous because it is both odorless and tasteless. It is formed by incomplete combustion and reacting carbonyls. MAC, 100 ppm in air. Explosive range, 12.5-74.2%.

Carbon tetrachloride has a strong narcotic action and can cause serious kidney and liver damage. MAC, 25 ppm in air. When heated to decomposition, it emits highly toxic fumes of phosgene.

Chlorine and hydrogen or various hydrocarbons can ignite spontaneously. Chlorine and gaseous formaldehyde can react explosively under certain conditions at temperatures as low as 100°C. MAC, 1 ppm in air. Extremely irritant to mucous membranes of eyes and respiratory tract. Incompatibles: turpentine, ether, ammonia gas, illuminating gas, hydrocarbons, hydrogen, powdered metals, sodium carbide, benzene, sodium and potassium metal.

Diazonium compounds react vigorously with sodium sulfide or hydrogen sulfide and are known to explode. They are a severe explosion hazard when exposed to heat, shock, or chemical reaction.

Dimethyl sulfoxide decomposes violently when in contact with a wide range of acyl halides and related compounds, such as cyanuric, acetyl, benzoyl, benzenesulfonyl, thionyl, phosphoryl chlorides, and PCl_3. DMS should be used with caution as a solvent in exploratory reactions. Unknown toxicity. Flash point, 203°F. (O.C.).

Ethers - Diethyl ether is very flammable at room temperature. It has a high vapor pressure, low flash point, and low ignition temperature. Mixtures of ether vapor with air are explosives over a wide range. The following ethers form peroxides on storage: isopropryl ether, diethyl ether, diethylene ether, tetrahydorfuran, ethylene glycol dimethyl ether, and diethylene glycol dimethyl ether. Sunlight hastens the reaction. These materials should be discarded after 1 year if unopened, and within 3 months after opening. Another group including all other ethers, all liquid paraffins, all olefins, tetralin (tetrahydronaphthalene), and aromatics (excluding benzene and toluene) form peroxides on concentration by distillation or evaporation. In any case, at least 10% undistilled residue should be left in still pots. These light materials should not be poured into sinks. Waste can should be grounded when pouring.

Fluorine is extremely active and hazardous at 20° C; mixtures of F and ClO_2 react explosively to form chlorine and oxygen. Handling procedure is given in sheets published by The Matheson Company.

Hydrazine vapor, when sparked at 100° C, explodes with a yellow flame, producing ammonia, hydrogen, and nitrogen. It is a very sensitive explosive. Very toxic. MAC, 1 ppm in air.

Hydrogen is a very dangerous explosive hazard. Explosive range, 4.1-74.2%. Waste gas is best burned with a quiet flame.

Hydrogen chloride gas is a primary irritant with a destructive action on mucous membranes. MAC, 5 ppm in air.

Hydrogen cyanide and other cyanides and cyanogens are well-known highly poisonous compounds. Poisoning proceeds very rapidly, causing a reflex cessation of the heart action so that first aid generally comes too late. Flash point of HCN, 0°F (C.C.). MAC, 10 ppm. If in contact with alkaline materials, HCN can polymerize or decompose explosively. Incompatible with nitric acid.

Hydrogen fluoride is a poison with a strongly irritant action on the skin and the mucous membranes. The concentrated acid produces open wounds which heal slowly. Soluble fluorides are toxic. Particular care should be taken that no HF gets under the fingernails, as this causes painful and prolonged inflammation.

Hydrogen peroxide detonates rapidly in the pure state, but will not detonate in aqueous solutions containing less than 94% H_2O_2, although aqueous solutions will decompose explosively under catalytic influence. Such catalysts are copper, chromium, iron, and most metals and their salts. H_2O_2 causes burns which should be treated with hot water or with a solution of sodium thiosulfate. In concentrations above 50%, H_2O_2 can be a fire hazard in the presence of easily oxidizable material. Mixed with organic material such as glycerine, aniline, or nitromethane, it is unusually explosive, expecially when contaminated. Storage containers even for diluted solutions should be vented because of gradual decomposition to water and oxygen.

Hydrogen sulfide is very poisonous; MAC, 20 ppm in air. Low concentrations have a very disagreeable odor, but higher concentrations and even relatively short exposure cause the sense of smell to become temporarily atrophied. Explosive range 4.3-46%. Excess gas is easily disposed of by burning in a hood.

Lithium aluminum hydride is not safe for drying methyl ethers. Tetrahydrofuran can cause fire when used as a solvent for $LiAlH_4$. Extreme caution should be used in reducing any fluorinated compound with $LiAlH_4$. Violent reactions have been observed with two different fluor compounds. Excess trimethyl amine, NMe_3, reacts with an ethereal solution of $LiAlH_4$ in vacuo at -50°C to form a white addition compound which is slightly soluble in ether, insoluble in benzene, and spontaneously flammable in air. For particulars in handling and using this material, see the publications of Metal Hydrides Incorporated.

Magnesium perchlorate may be used as a very effective drying agent and as a quantitative absorbent of vapors of some polar compounds. Caution must be taken to exclude flammable materials, mineral acids, or substances liable to hydrolyze them. Serious explosions have resulted from using magnesium perchlorate for drying an organic liquid which had been in contact with sulfuric acid and had been inadequately washed. The compound used in drying unsaturated hydrocarbons exploded on heating to 220°C. See the bulletin of the G. Frederick Smith Chemical Company.

Mercaptans of low molecular weight generally have a very strong odor which may cause nausea and headache. High concentrations can produce unconsciousness. When heated to decomposition, they emit highly toxic oxides of sulfur. They will react with water, steam, or acids to produce toxic and flammable vapors, and can react with oxidizing materials.

Mercuric nitrate and organic compounds react vigorously and exothermally at room temperature without exploding during attempts to remove sulfides.

Mercury and ammonia gas are known to explode. The MAC for Hg is very low: 0.01 ppm in air. Clean up spills immediately.

Nitric acid (concentrated) attacks the skin, forming a yellow stain which remains for a considerable period of time. The vapor is a serious respiratory poison. Use of a face shield, protective clothing, and adequate ventilation are imperative. HNO_3 is a powerful oxidizing agent, causing fire and explosion hazards when mixed with combustible materials. Mixtures of the concentrated acid and an organic substance such as acetone, acetic anhydride, alcohol, or aniline may detonate. Traces of an organic substance with HNO_3 and mercury may form a highly explosive fulminate.

Nitro compounds are very toxic. They may enter the body via the lungs, through the skin, or with food. Recovery from poisoning with nitro compounds is slow. Protection against such poisons is based on cleanliness, ventilation, protective clothing, goggles, and respirators. These statements apply as well to nitrobenzenes, nitromethanes, and nitrochlorobenzene.

Nitrogen oxide fumes are most hazardous, as they can develop unexpectedly (e.g., when a bottle of HNO_3 breaks, or when HNO_3 comes into contact with organic substances such as sawdust). Any atmosphere in which nitrogen oxides can be smelled must be considered dangerous. Reactions in which nitrogen oxides may be produced must be performed in a hood. MAC for nitric oxide is 25 ppm in air.

Nitroparaffins are sensitive to alkali, and many sensitive combinations ranging from addition complexes, through metal salts, to the very dangerous fulminates, can be formed, depending on the base involved. All these compounds are usually more sensitive than the original nitroparaffin.

Oxygen - Incompatibles: oils, greases, hydrogen, and flammable liquids and solids. Do not oil reducing gauges or fittings.

Perchlorates in mixtures with reducing materials are more stable than the corresponding chlorates and are not as subject to dangers from the presence of free acids. It should not be assumed that all perchlorate mixtures can be initiated by friction, impact, or spark.

Perchloric acid is an extremely powerful and dangerous oxidizing agent which may react explosively with reducing agents and organic compounds. It should be used with extreme caution and in the smallest quantities possible.

Perchloric acid should always be used in a noncombustible hood, preferably with flushing facilities. Before the acid is used, the exhaust fan should be run for a few minutes to remove all loose particles of dust, etc., from the hood.

Solutions of perchloric acid should be heated with an electric hot plate or a heating mantle, and never in an oil bath.

Organic matter in samples should first be oxidized with concentrated HNO_3 before adding the $HClO_4$. Never heat $HClO_4$ with sulfuric acid or any other high-boiling acid, as dehydration will produce the explosive anhydrous $HClO_4$.

Combustible materials (filter paper, rags, etc.) which have been soaked with aqueous $HClO_4$ and dried, should be treated with extreme care as they may be ignited by impact, friction, or heat. The condensed vapor will form explosive mixtures with ammonia or with HNO_3.

Never use rubber or cork with apparatus when working with $HClO_4$. Use an all-glass apparatus, and do not use stopcock grease.

The 60-70% commercial acid is stable and can be stored safely. At concentrations above 85%, the acid is liable to spontaneous explosion. Discolored (i.e., contaminated) acid should be poured carefully into cold water and flushed. Perchloric acid reacts with bismuth to form a spontaneously explosive compound.

Perchloric acid esters are violently explosive. An alcoholic solution of $HClO_4$ should never be heated unless considerable water is present, as it may explode.

Phosphorous trichloride - An explosion occurred in the preparation of acetyl chloride from acetic acid and PCl_3, the AcCl being distilled with a free flame. PH_3 is believed to have been the cause. PCl_3 reacts with water to give phosphine, which ignites spontaneously. MAC, 0.5 ppm in air.

Sodium covered with sodium methylate or butylate, formed in the presence of toluene, explodes when thrown into water. It should be noted that metallic sodium reacts exothermally with the moisture of body or tissue surfaces, causing thermal and chemical burns due to the reaction with sodium and the sodium hydroxide formed. Only dry sodium chloride, sodium carbonate, or graphite should be used for fighting fires.

Sodium borohydride is a very useful reducing agent like lithium aluminum hydride. See the Metal Hydrides manual.

Concentrated sulfuric acid and oleum cause burns on the skin and have a destructive action on all organic matter. Concentrated H_2SO_4 sometimes reacts violently with many organic substances, nitrates, sulfides, chlorates, perchlorates, halogenides, carbides, and many metals. Concentrated H_2CO_4 should never be used in a desiccator unless it is certain there will be no reaction with the material to be dried. Accidental spills have caused explosions.

Toluene is less toxic than benzene (MAC, 200 ppm), but more dangerous than xylene. Flash point, 40°F (C.C.); explosive range, 1.27-7.0%.

Trichlorethylene, often recommended for use in place of CCl_4; is about "half" as toxic, and is often used instead of it. Some persons even grow addicted to it. MAC, 200 ppm in air.

Xylene, although toxic, is less dangerous than toluene or benzene. It is more irritating to the skin than is benzene. Flash point, about 77°F; MAC, 200 ppm in air.

Reference

1. See Section IIID Handling Chemicals. Curriculum Instructors Manual, 1970.

Appendix G:

SUPPLIERS FOR SAFETY EQUIPMENT AND SERVICES

Abso-Clean Chemical Company
17325 Lamont
Detroit, Michigan 48212
(Cleaning Chemicals & Equipment)

Aden Supply Company
5706 W. River Dr., N.E.
Belmont, Michigan 49306
(Safety Glasses)

Advertisers Publishing Co.
944 Wall Street, PO Box 602
Ann Arbor, Michigan 48107
(Custom imprinted safety awards)

Airkem Detroit, Inc.
404 West Eight Mile Road
Ferndale, Michigan 48220
(Odor Control)

The Ansul Company
16115 Meyers Road
Detroit, Michigan 48235
(Fire Protection Products)

Argus Supply Company
5940 Casmere
Detroit, Michigan 48212
(Ind. Safety & Fire Equipment)

Averill Equipment Company
19225 Conant Avenue
Detroit, Michigan 48234
(Safety Distributor)

Bemis & Son, Inc.
P.O. Box 151
Kalamazoo, Michigan
(Traffic Control)

Boyer Campbell & Sales
19460 Charleston
Detroit, Michigan 48203
(Safety Products)

Broner Glove Company
345 E. 9 Mile Road
Ferndale, Michigan 48220
(Industrial Work Gloves)

A.J. Baxter & Company
10171 W. Jefferson
River Rouge, Michigan
(Industrial Safety Products)

Contractor Machinery Company
13200 North End Avenue
Detroit, Michigan
(Construction Equipment)

Dockson Corporation
3839 Wabash Avenue
Detroit, Michigan 48208
(Head & Eye Protection)

Goodall Rubber Company of Michigan
13351 Cloverdale Avenue
Oak Park, Michigan 48237
(Industrial Rubber Goods)

Hastings Fiber Glass Products
770 S. Cook Rd., Box 218
Hastings, Michigan 49058
(Hot Line Maintenance Tools)

Howe Services, Inc.
National Bank Building
Birmingham, Michigan 48011
(Message Motivation Programs)

Hy-Test Div., International Shoe Co.
32302 Craftsbury
Farmington, Michigan
(Safety Equipment & Welding Accessories)

Magline, Inc.
503 S. Mercer Street
Pinconning, Michigan 48650
(Magnesium Safety Blocks for Presses)

Mine Safety Appliances Company
19725 Ralston
Detroit, Michigan
(Safety Equipment)

National Safety Products, Inc.
116 North Hamilton Street
Saginaw, Michigan 48602
(Industrial Safety Equipment)

Port Products, Inc.
325 Main Street
Munith, Michigan
(Signs and Safety Equipment)

Jackson Products
5523 E. Nine Mile Road
Warren, Michigan 48091
(Safety Equipment & Welding Accessories)

113

The Protectoseal Company
Power Materials Company
633 New Center Bldg.
Detroit, Michigan 48202
(Safety Containers)

R - J Distributing Company
11566 E. Nine Mile Road
Warren, Michigan 48089
(Reynolds Televator-Power Scaffold)

Safeco, Inc.
24295 Gibson Drive
Warren, Michigan 48090
(Industrial Safety)

Safety Products & Services, Inc.
184 Avenue A
Battle Creek, Michigan 49015
(Safety Equipment Sales & Service)

Safety Services, Inc.
407 East Michigan Avenue
Kalamazoo, Michigan 49006
(Industrial Safety Equipment Supplies)

Seco Manufacturing, Inc.
4461 W. Jefferson
Detroit, Michigan
(Safety Equipment and Supplies)

Speidel Safety Service
600 W. Commerce Road
Milford, Michigan 48042
(Industrial Safety Sales)

Standard Glove Company
28252 Terrace
Livonia, Michigan 48154
(Safety Gloves)

Stewart Oxygen Service
19142 James Couzens Highway
Detroit, Michigan 48235
(Oxygen Therapy Equipment)

Tool Sales Company
46 Victor Avenue
Highland Park, Michigan 48203
(Safety Tools)

Wallace Optical
2870 E. Grand Blvd.
Detroit, Michigan
(Safety Glasses)

Wallace Opticians
107 N. Washington Avenue
Lansing, Michigan 48933
(Prescription Safety Glasses)

E. L. West Company
1020 E. Jolly Road
Lansing, Michigan 48910
(Construction Safety)

LeHigh Safety Shoe Company
14234 Woodmont Road
Detroit, Michigan 48227

Midwest Safety Supply
621 Liberty Street
Jackson, Michigan 49203
(Industrial Safety Equipment)

Fisher Scientific Co.
711 Forbes Ave.
Pittsburgh, Penn. 15219

Sargent Welch Scientific Co.
7300 North Linden Ave.
Skokie, Ill. 60076

Turtox/Cambosco
Macmillan Science Co. Inc.
8200 S. Hoyne Ave.
Chicago, Ill. 60620

Science Kit Inc.
777 East Park Drive
Tonawanda, New York 14150

Central Scientific Co. (CENCO)
2600 South Kostner CENCO Center
Chicago, Ill. 60623

Sugar Beet Products Company
302 Waller Street
Saginaw, Michigan 48605
(Industrial skin cleansers & medicated skin cream)

114

Appendix H:

DEPARTMENT OF LABOR

OCCUPATIONAL SAFETY STANDARDS COMMISSION

SAFETY STANDARDS

Filed with Secretary of State,

These rules take effect May 1, 1972 (as amended November 20, 1973)

(By authority conferred on the occupational safety standards commission by section 5 of Act No. 282 of the Public Acts of 1967, as amended, being section 408.855 of the Compiled Laws of 1948.)

PART 16 LABELING OF HAZARDOUS SUBSTANCES

R 408.11601. Scope.

Rule 1601. This part provides for warning label requirements for containers holding hazardous substances when such containers are used, handled or stored by employees covered by the act.

R 408.11604. Definitions C to E.

Rule 1604. (1) "Combustible liquid" means a liquid which gives off flammable vapors above 80 degrees fahrenheit to and including 150 degrees fahrenheit as determined by an approved flash point test.

(2) "Container" means a portable individual package, such as but not limited to a bag, box, bottle, barrel, can, carboy or drum that is used to store or dispense a hazardous substance. A process tank, reactor, tank truck and tank car are excepted.

(3) "Corrosive" (physiological) means a substance which in contact with living tissue causes destruction of the tissue by chemical action.

(4) "Dust" means solid particles generated by handling, crushing, grinding, rapid impact, detonation or decrepitation of organic or inorganic material.

(5) "Extremely flammable liquid" means a liquid which gives off flammable vapors, at or below 20 degrees fahrenheit, as determined by an approved flash point test.

R 408.11605. Definitions F to H.

Rule 1605. (1) "Flammable liquid" means a liquid which gives flammable vapors above 20 degrees fahrenheit to and including 80 degrees fahrenheit as determined by an approved flash point test.

(2) "Fume" means solid particles generated by condensation from a gaseous state, generally after volatilization from molten metals, and often accompanied by a chemical reaction such as oxidation.

(3) "Gas" means a normally formless fluid which occupies a space or enclosure and which can be changed to the liquid or solid state by the effect of increased pressure or decreased temperature or both.

(4) "Hazardous substance" means a substance or mixture of substances which is toxic, corrosive, an irritant, a strong sensitizer, flammable or which generates pressure through decomposition, heat or other means, if the substance or mixture or substances may cause substantial personal injury or substantial illness during or as a direct result of a customary or reasonable anticipated handling or use.

(5) "Highly toxic" means a substance which falls within any of the following categories:

(a) Produces death within 14 days in half or more than half a group of 10 or more laboratory white rats each weighing between 200 and 300 grams, at a single dose of 50 milligrams or less per kilogram of body weight, when orally administered.

(b) Produces death within 14 days in half or more than half a group of 10 or more laboratory white rats each weighing between 200 and 300 grams, when inhaled continuously for a period of 1 hour or less at an atmosphere concentration of 200 parts per million by volume or less or gas or vapor or 2 milligrams per liter by volume or less of mist or dust, provided such concentration is likely to be encountered by man when the substance is used in any reasonably foreseeable manner.

(c) Produces death within 14 days in half or more than half a group of 10 or more rabbits tested in a dosage of 200 milligrams or less per kilogram of body weight, when administered by continuous contact with the bare skin for 24 hours or less. If available data on human experience with any substance in the concentrations listed in subrules (a), (b) or (c) indicate results different from those obtained on animals, the human data shall take precedence in any classification of a substance as "highly toxic".

R 408.11606. Definitions I to O.

Rule 1606. (1) "Irritant" (physiological) means a substance which on immediate, prolonged or repeated contact with normal living tissue induces a local inflammatory reaction.

(2) "Label" means a display of legibly written, printed or graphic matter upon the immediate container of a substance covered by this part which label includes the requirements of this part.

(3) "Mist" means suspended droplets generated by condensation from the gaseous to the liquid state or by breaking up a liquid state into a dispersed state, such as by splashing, foaming or atomizing.

(4) "Mixture" means a physical commingling of 2 or more substances which have not reacted chemically with each other.

(5) "Oxidizing material" means a substance that yields oxygen readily to stimulate the combustion of organic matter.

R 408.11607. Definitions S to V.

Rule 1607. (1) "Strong sensitizer" means a substance that shows from available data on human experience to be capable of inducing an allergic reaction in approximately 1% of the persons who come in contact with it.

(2) "Toxic" means a substance which falls within any of the following categories:

(a) Produces death within 14 days in 1/2 or more of 10 or more laboratory white rats each weighing between 200 and 300 grams, at a single dose of more than 50 milligrams but not more than 500 milligrams per kilogram of body weight, when orally administered.

(b) Produces death within 14 days in half or more than half a group of 10 or more laboratory white rats each weighing between 200 and 300 grams, when inhaled continuously for a period of 1 hour or less at an atmosphere concentration of more than 200 parts per million but not more than 2000 parts per million by volume of gas or vapor or 2 milligrams per liter by volume or less of mist or dust, provided such concentration is likely to be encountered by man when the substance is used in any reasonably foreseeable manner.

(c) Produces death within 14 days in half or more than half a group of 10 or more rabbits tested in a dosage of more than 200 milligrams but not more than 1000 milligrams per kilogram of body weight, when administered by continuous contact with the bare skin for 24 hours or less. If available data on human experience with any substance in the concentrations listed in subrules (a), (b) or (c) indicate results different from those obtained on animals, the human data shall take precedence in any classification of a substance as "toxic".

(3) "Vapor" means the gaseous form of a substance which is normally in the solid or liquid state.

R 408.11611. General labeling requirements.

Rule 1611. (1) A container of hazardous substances shall be labelled pursuant to this part.

(2) A container of hazardous substances shall not be accepted by an employer for use or handling by his employees unless the container is labelled pursuant to this part.

(3) An employer shall not distribute, make available, furnish or supply a hazardous substance for use by his employees unless labelled pursuant to this part. Excepted are containers of 1 quart capacity or less holding samples of hazardous substances for in-plant use. These quart or less containers shall carry a label with an identification name and statement of the hazard.

R 408.11612. Specific labeling requirements.

Rule 1612. (1) A label shall be placed on a container of a hazardous substance or, in case of a mixture, the primary hazard which would be most likely to cause an adverse effect on an employee, and such label shall contain the following appropriate information pursuant to this part and table 1 (see table 2 for typical labels):

(a) A product name, trade name, chemical name or generic name. It is recommended that the chemical or generic name be included if the product or trade name is used.

(b) A signal word to draw attention and designate the degree of hazard as follows:

(i) DANGER shall mean the most serious hazard.

(ii) WARNING shall mean a lesser hazard.

(iii) CAUTION shall mean the least hazard.

(c) A statement including but not limited to, "causes burns" or "vapor hazardous", as to hazards that are present with customary use or handling of the substance.

(d) Instructions on measures to avoid injury, including but not limited to, "keep away from open flame" or "avoid breathing dust".

(e) Treatment instructions where the result of contact or exposure are severe and immediate treatment is desirable.

(2) Compressed gases carrying an approved department of transportation label shall be deemed to comply with this part.

(3) A label required by this part shall be located prominently on the container. Printing shall be legible and in contrast by typography and layout to other printed matter.

(4) A hazardous substance which requires special handling or storage shall have instructions covering this point included on the warning label or a separate label.

(5) If a container is too small to permit printing the entire precautionary labelling in legible size, the labelling may be condensed as follows:

(a) Retain the signal word.

(b) Retain the word poison or the "skull and cross bones", where required on the label.

(c) Retain the statement of hazard, shortened if possible to a practical equivalent. Consider omitting statements for hazards which are less serious because of size of the package or use of the product.

(d) Omit minor precautionary measures, or combine precautionary measures with statement of hazard.

(e) If necessary in order to permit printing the warning in a legible size, the precautionary labeling may be placed on a cardboard or heavy paper tag securely attached to the immediate container.

R 408.11613. Cleaning of containers.

Rule 1613. An employer shall not distribute, make available, furnish or supply a container known to have contained a hazardous substance unless the container has been thoroughly cleaned to remove all traces of any hazardous substance, except where refilled with the same substance.

FOOTNOTES

1. In addition to the use of POISON and skull and crossbones in the highly toxic classes shown on the following page, certain laws may require this use in other specified instances.

2. Examples of Antidote Statements; Examples of Notes to Physicians; Instructions in Case of Fire, Spill, or Leak; and Instructions for Container Handling and Storage are illustrated separately.

3. Products may present a special or unique hazard not covered in this table. For example, some chemicals may react violently with water, may liberate extremely poisonous vapors under special conditions, etc. These special conditions must be covered in the precautionary label text.

4. The First Aid instructions for Class of Hazard INGESTION are considered to be applicable in the vast majority of cases involving the ingestion of a poison. In all cases, a study of the particular product involved and the applicable laws may dictate either additional or completely different First Aid Instructions.

5. Eyes shall be protected as specified in Part 35, Face and Eye Protection of the Occupational Safety Standards Commission standard, being R 408.13501 through R 408.13569 of the Michigan Administrative Code.

6. Controlled ventilation shall be provided to maintain exposure limits below maximum allowable concentration as defined in Michigan Department of Public Health, Basic Guide for Control of Occupational Air Contaminates and Physical Agents being R 325.2401 of the Michigan Administrative Code.

TABLE OF EXAMPLES-SELECTION OF PRECAUTIONARY STATEMENTS

	Class of Hazard	Signal Word	Statements of Hazard	Precautionary Measures	Instructions in Case of Contact or Exposure
INGESTION	Highly Toxic	DANGER!	MAY BE FATAL IF SWALLOWED	Wash thoroughly after handling.	POISON Call a Physician FIRST AID: If swallowed dilute by giving several glasses of water, soapy water, salty water (1 Tbs. per glass), milk, or by sticking finger down throat. If vomiting occurs repeat several times. Never induce vomiting or give anything by mouth to a victim having convulsions or unconscious.
ABSORPTION	Highly Toxic	DANGER!	MAY BE FATAL IF ABSORBED THROUGH SKIN	Do not get in eyes, on skin, on clothing. Wash thoroughly after handling. XX	POISON Call a Physician FIRST AID: In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before re-use. (Discard contaminated shoes.)
INHALATION 96	Toxic	WARNING!	HARMFUL IF INHALED	Avoid breathing (dust, vapor, mist, gas). Keep container closed. Use with adequate ventilation. XX	FIRST AID: If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Call a physician.
CONTACT	Corrosive, Eye and Skin	DANGER!	CAUSES (SEVERE) BURNS	Do not get in eyes, on skin, on clothing. Avoid breathing (dust, vapor, mist, gas). Keep container closed. Use with adequate ventilation. Wash thoroughly after handling. XX	FIRST AID: In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Call a physician. Wash clothing before re-use. (Discard contaminated shoes.)

	Class of Hazard	Signal Word	Statements of Hazard	Precautionary Measures	Instructions in Case of Contact or Exposure
FLAMMABILITY	Extremely Flammable Liquid	DANGER!	FLAMMABLE	Keep away from heat, sparks, and open flame. Keep container closed. Use with adequate ventilation. XX	